PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXV.—No. 2992.] *LONDON: FRIDAY, MAY 4, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See half-page Advertisement, page 63, April 13.

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TENDERS.

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to Receive up to noon on Thursday, 24th May,

Tenders for the Supply of :—

1. TYRES for Carriages and Wagons,
2. WHEELS AND AXLES for Carriages and Wagons,
3. AXLES for Carriages and Wagons,
4. COPPER FIREBOX PLATES.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices, on payment of 20s. each for Nos. 1 and 2 and 10s. each for Nos. 3 and 4 (which will Not be returned).
The Directors do not bind themselves to accept the lowest or any Tenders.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France, Westminster, S.W. 1.
1st May, 1923. A 394

TO MARINE ENGINEERS, SHIP REPAIRERS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD invite

Tenders for Dry-docking and carrying out certain repairs to HULL and MACHINERY of Training Ship "Exmouth," now lying off Grays, Essex, in accordance with specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The specification and form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C. 4, on and after Ten a.m., Monday, May 7th, 1923, and the specification and form of Tender can then be obtained upon payment of a deposit of £1 in respect of such work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the form of Tender and after the specification has been returned. Tenders as addressed as noted on the form, must be delivered at the Office of the Board not later than 2.30 p.m. on 23rd May, 1923.

By Order;
G. A. POWELL,
Clerk to the Board. A 385

TO ELECTRICIANS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD invite

Tenders for the Installation of ELECTRIC LIGHTING in the Administrative block, Engineers' Office block, Wards 1 to 10, and Isolation Ward block at the North Western Fever Hospital, Lawn Road, Hampstead, N.W., in accordance with drawings and specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Drawings, Specification and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C. 4., on and after Ten a.m. on Monday, 7th May, and the Drawings, Specification and Form of Tender can then be obtained upon payment of a deposit of £1 in respect of the work. The amount of the deposit will be returned only after the receipt of a *bona-fide* Tender sent in accordance with the instructions on the Form of Tender and after the specification and the drawings have been returned.
Tenders, addressed as noted on the Form, must be delivered at the office of the Board, not later than 2.30 p.m., on 23rd May, 1923.

(By Order)
G. A. POWELL,
Clerk to the Board. A 406

STATE ELECTRICITY COMMISSION OF VICTORIA.

AUSTRALIA.

Tenders are Invited for the MANUFACTURE, SUPPLY, DELIVERY and SUPERINTENDENCE of ERECTION of the following:—

SPECIFICATION No. 23/63.

ELECTRICALLY OPERATED POWER SHOVEL.

Tender forms, Specification, Contract Conditions, etc., are available upon application to
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

The charge per one set of two copies of the Specification is £1 which will be refunded on receipt of a *bona fide* Tender and the return of all documents supplied.
Tenders on prescribed forms accompanied by a deposit of £50 and endorsed "SPECIFICATION 23/63.—ELECTRICALLY OPERATED POWER SHOVEL," will be received up to Noon on the 31st July, 1923, by

R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
23-33, William Street, Melbourne.

The Commission does not bind itself to accept the lowest or any Tender. A 253

MANCHESTER CORPORATION TRAMWAYS.

The Tramways Committee of the Manchester Corporation are prepared to receive

Tenders for the Supply and DELIVERY of a DRILLING MACHINE. Specifications and Forms of Tender may be obtained on application to Mr. HENRY MATTINSON, General Manager, Corporation Tramways, 55, Piccadilly, Manchester. Tenders are to be addressed to the Chairman of the Tramways Committee, 55, Piccadilly, Manchester, endorsed "Tender for Drilling Machine," and *must be received not later than Ten a.m. on Monday, the 14th May*, 1923.
The Committee do not bind themselves to accept the lowest or any Tender.

P. M. HEATH,
Town Clerk.

Town Hall, Manchester,
5th May, 1923. A 406

TYNE IMPROVEMENT COMMISSION.

STEAM TRAVELLING CRANE.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Construction and DELIVERY at their South Pier Works, South Shields, of ONE FIVE-TON STEAM TRAVELLING CRANE.
Copies of the Form of Tender, Conditions of Contract and General Specification may be obtained from this Office on Payment of a deposit of £1, which will be returned on receipt of a *bona-fide* Tender.
Tenders in sealed envelopes endorsed "Tender for Steam Travelling Crane" must be addressed to the undersigned and delivered to him not later than Noon on Saturday, the 2nd June, 1923.
The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
RICHARD AUGHTON,
General Manager.

Tyne Improvement Commission Offices,
Newcastle-upon-Tyne,
4th May, 1923. A 407

CITY AND COUNTY OF NEWCASTLE-UPON-TYNE, QUAY EXTENSION: EAST OF OUSE BURN.

ELECTRIC TRAVELLING CRANES.

The Trade and Commerce Committee of the Council are prepared to receive

Tenders for the Supply and ERECTION of one 5-ton and two 3-ton ELECTRIC TRAVELLING GANTRY CRANES. Specifications and full particulars can be obtained at the Office of the City Engineer, Town Hall, Newcastle-upon-Tyne, on and after Wednesday, 9th May, 1923.
Tenders addressed to the City Engineer, and endorsed "Tenders for Electric Cranes," to be delivered not later than Ten a.m. on Wednesday, 30th May, 1923.
The Committee does not bind itself to accept the lowest or any Tender.

By Order.
A. M. OLIVER,
Town Clerk.

Town Hall,
Newcastle-upon-Tyne. A 428

ADMINISTRATIVE COUNTY OF LONDON.

ABBEY MILLS PUMPING STATION ENLARGEMENT, 1923.

The London County Council invites

Tenders for the Construction of FOUNDATIONS for a NEW INSTALLATION of ENGINES and PUMPS, BOILER FOUNDATIONS and ECONOMISER HOUSE, and the CONSTRUCTION of a NEW PUMPING MAIN between the Engine House and the Northern Outfall Sewers, and other works in connection therewith, at the Council's Abbey Mills Pumping Station, in the Borough of West Ham, in the County of Essex.
Persons desiring to submit Tenders may obtain the Form of Tender, Drawings, etc., on application to the Chief Engineer, at The Old County Hall, Spring Gardens, S.W. 1., upon payment of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.
No Tender received by the Clerk of the Council, at the County Hall, Westminster Bridge, after Four p.m. on Monday, 28th May, 1923, will be considered.
The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
A 420

COUNTY BOROUGH OF SOUTHPORT.

SALE OF REPLACED ELECTRICAL PLANT, ETC.

The Electricity Committee of the Southport Corporation are prepared to receive

Offers for the Purchase of :—

1. 100/1250 HP. Bellias Marcom, High-Speed Engine, Direct Coupled to one British Westinghouse 700 Kw. S.P. Alternator, and a 200 Kw. Bruce Peebles D.C. Generator.
2. 1000 HP. Musgrave High-Speed Engine, Direct Coupled to one British Westinghouse 800 Kw. 3 P. Alternator.
3. 500 HP. Musgrave Horizontal Slow-Speed Engine, Direct Coupled to a Ferranti 300 Kw. S.P. Alternator.
4. Two 250 HP. Musgrave Horizontal Slow-Speed Engines, each Direct Coupled to a Ferranti 125 Kw. S.P. Alternator.
5. One Jet Condenser, complete with Engine-Driven Air Pumps.
6. One Surface Condenser, complete with Electrically-Driven Circulating Water and Air Pumps.
7. One Worthington Boiler Feed Pump.

Full particulars and Tender form can be obtained on application to Mr. E. MOXON, A.M.I.E.E., Borough Electrical Engineer, 93A, Eastbank Street, SOUTHPORT.
The highest or any Tender will not necessarily be accepted. A 422

DEPARTMENT OF PUBLIC WORKS, Sydney, 31st January, 1923.
SYDNEY HARBOUR BRIDGE TENDERS—EXTENSION OF TIME.

Tenders are Invited by the Government of New South Wales for the CONSTRUCTION OF THE SUPERSTRUCTURE AND SUBSTRUCTURE OF A CANTILEVER BRIDGE ACROSS SYDNEY HARBOUR FROM DAWES POINT TO MILSON'S POINT, embracing a main span of 1600 feet in the clear, centre to centre of main piers, and a length of main bridge 2600 feet centre to centre of anchor piers. The total length of main bridge and approach spans included in tender is 3810 feet; also an ALTERNATIVE TENDER for the CONSTRUCTION OF THE SUPERSTRUCTURE AND SUBSTRUCTURE OF AN ARCH BRIDGE ACROSS SYDNEY HARBOUR FROM DAWES POINT TO MILSON'S POINT, embracing a main span of 1650 feet in the clear centre to centre of bearings. The total length of main bridge and approach spans included in tender is 3770 feet. Either bridge is to provide for four lines of railway, six lines of vehicular traffic, and footway accommodation.
Copies of Specification, including Plans, Technical Information, General Conditions, and Tender Forms, may be obtained by *bona fide* tenderers on application to the Under Secretary for Public Works, Sydney, or to the Agent-General for New South Wales, Australia House, The Strand, London; the Minister of Railways and Canals, Ottawa; The Australian Trade Commissioner in the United States, New York; or the Bureau of Foreign and Domestic Commerce, Washington, D.C., United States.
Tenders, the time for which has been extended, must reach the Under Secretary for Public Works Sydney, New South Wales, not later than 30th November, 1923.

R. T. BALL,
Minister for Public Works and Railways. A 59

APPOINTMENTS OPEN.

CITY AND GUILDS (ENGINEERING) COLLEGE, S.W. 7.

Assistant Professorship in ELECTRICAL ENGINEERING DEPARTMENT.
Owing to the appointment of Dr. Parker Smith to the Chair of Electrical Engineering at the Royal Technical College, Glasgow, the Delegacy will proceed shortly to the APPOINTMENT of an ASSISTANT PROFESSOR to deal particularly with the Traction and design sections of the Electrical Engineering Department. Candidates for the post will be expected to have had some experience of this work. Full particulars can be obtained from the SECRETARY TO THE DELEGACY, The City and Guilds (Engineering) College, S.W. 7. A 404

Works Manager Wanted for General Engineering Works, employing 700-1000 hands; must be thoroughly practical, good organiser, and a producer. Knowledge of Pattern Making, Foundry and Machinery essential.—Address, in confidence, giving details of experience, age, qualifications and salary, A 387, Offices of ENGINEERING.

CO_2 Recorders. — Wanted, SALES MANAGER, thoroughly competent on the subject, able to take complete control of the sale organisation for the above apparatus. None without the necessary experience need apply. Applicants should send full particulars of their experience and salary required.—Address, A 373, Offices of ENGINEERING.

Applications are Invited for the POST of MECHANICAL ENGINEER and WORKS MANAGER, for the large miscellaneous Engineering Works of a Public Company near London. Age not to exceed 45, and experience in Electricity and Metallurgy and in the control of Staff and Works organisation essential. Commencing salary £1000 to £1200 according to experience.—Apply before May 12th with copies only of testimonials to BOX G.W.J., care of DAVIES & CO., 95, Bishopsgate, E.C. 2. A 372

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Wanted, Inspector for General Engineering Works; must be experienced in maintaining a high standard of Machine Shop Practice.
Applicants state age, experience and salary.
Address, A 386, Offices of ENGINEERING.

Works Cost Accountant REQUIRED, with experience in engineering accounts, in Manchester district.—Address, with full particulars and salary required, A 401, Offices of ENGINEERING.

Wanted, Young Engineering JOURNALIST with previous experience of technical Journalism and technical advertising to undertake whole-time publicity work in connection with Electrical, Hydraulic, Textile and Fire Engineering productions.
Apply by letter only in own hand-writing giving full particulars of training, attainments and experience, also salary required, to MATHER & PLATT, LTD., Park Works, Manchester. A 402

Wanted, Organiser to Control an Important Section of the Sales Department of an Engineering Works. Must be experienced administrator. Knowledge of engineering and publicity work required.—Apply, giving full particulars of age, experience, and salary required, to HANS RENOLD, LTD., Burnage Works, Didsbury, Manchester. A 418

Wanted, Engineer for Foreign Sales Department. Well educated, good practical and technical training, also selling experience. French and commercial experience also essential.—Apply, giving full particulars of age, experience and salary required, to HANS RENOLD, LTD., Burnage Works, Didsbury, Manchester. A 417

Clerk (age 21 to 26) Required in Buying Department of Export Merchant Engineering Firm (Westminster). Knowledge of shorthand necessary. Only those having experience in similar post need write. Salary £250 p.a. to commence.—Address fullest particulars to "F. G.," c/o J. W. VICKERS & Co., LTD., 5, Nicholas Lane, E.C. 4. A 421

Power House Engineer REQUIRED by the GOVERNMENT OF THE GOLD COAST (Takoradi Harbour Works) for one tour of 12 to 18 months' service, with possible extension. Salary £540 a year. Outfit allowance of £45 on first appointment. Free quarters and passages, and liberal leave in England on full salary.
Candidates age 25 to 40, should have had a thorough experience of boilers, steam engines, electric generating plant, switchboard and wiring work, air compressors, rock crushers, pipe work and refrigerating plant for cold storage.—Apply, By letter, stating age, whether married or single, and qualifications and experience, to Messrs. STEWART and McDONNELL, 6/7, Cowley Street, Westminster, S.W.1. A 388

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Required, for Service with the Trust, a SECOND TECHNICAL ASSISTANT, age 25-30, unmarried, on a three years' Agreement, with possible extension. He must have had a good general education and technical training as Civil Engineer. Preference will be given to candidates who have passed the examination and hold the diploma of the Institution of Civil Engineers, or of the Institution of Municipal and County Engineers, or of the Town Planning Institute. It will be an advantage if candidates possess personal experience as Assistant Engineers in the working of the British Housing and Town Planning Acts (1875, 1890, 1909 and 1919), viz.:—The Improvement of Congested Dwelling Areas, Re-Housing, General Housing Schemes, Land Development for Housing, Re-Planning and Land Re-Distribution Schemes, Suburban Planning, including the usual work for surveys, roads, lay-outs, and general town planning.
The salary will be 6000 dollars for the first, 6480 dollars for the second, and 6960 dollars for the third year, paid monthly in dollars (the currency of the Colony), the value of the dollar being two shillings and fourpence sterling. The pay of the appointment for the first year at this rate would be £700. A local transport allowance, subject to variation from time to time as may be sanctioned by the Trust, will be paid. Free first-class passage will be provided, with half pay during the voyage out. The selected candidate must pass a medical examination.
Applications, stating whether married or single, age, and giving concise dated details of education, training and experience in general (including War Service) if any, with full details of experience in the above class of work, must be accompanied by copies of testimonials and personal references, and be lodged with Messrs. C. LINDSAY & PRIEST, M.M.Inst.C.E., 180, Hope Street, Glasgow, Agents to the Trust, not later than Tuesday, 15th May, 1923. A 393

Reinforced Concrete Designer WANTED. Must be experienced and capable of undertaking difficult work on own initiative. Apply, giving full particulars.—Address, A 409, Offices of ENGINEERING.

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Wanted, by Well-known Internal Combustion Engine Manufacturers DESIGNER capable of developing under the chief line of high Compression Oil Engines (Land and Marine) from present experimental stage to production stage. Only fully qualified need apply, stating experience and salary.—Address, COMBUSTION, Wm. PORTEOUS & Co., Advertising Agents, Glasgow. A 390

THE DESIGN OF HOT-AIR DRYING PLANT.

By GEORGE H. GILL.

(*Concluded from page* 512.)

CALCULATION OF THE AIR SUPPLY.

IN this section, the requirements of a dryer of the Tunnel type, working on the ordinary inverse principle, will be considered. To design an efficient dryer, the data given in inquiry must include: (1) The weight of material wet and dry; (2) the bulk it occupies in a wet state; (3) the weight required dry in a given time; (4) the maximum permissible temperature.

It is usual in calculations, to aim for a saturation of 66 per cent. at outlet of dryer and to assume that the outside atmosphere is saturated. The first step is to select the general type of dryer to employ, and a suitable range of temperature in the dryer based on the given maximum permissible temperature for the material.

The following inlet and corresponding outlet temperatures will be found to be satisfactory :—

Air inlet to dryer ...	70	80	90	100	110	120	130
Air outlet from dryer ...	64	68	71	74	77	79	82
Air inlet to dryer ...	140	150	160	170	180	190	200
Air outlet from dryer ...	84	86	88	90	91	93	95

As the inlet temperature is increased, the necessary heat is carried to the dryer by a less weight of air, which then becomes insufficient to absorb the moisture without exceeding the suggested limit of 66 per cent. saturation. Therefore the outlet temperature must be raised with inlet temperature. Having selected the temperature range, the size of dryer must be considered, and it is then necessary to estimate the time each unit of material must be subjected to the action of the heated air. The time to dry can often be obtained from the client, who may already have a dryer at work. The data given under "Rate of Drying" must be considered, and an estimate made for the proposed conditions. To simplify matters, we will assume a case and calculate a Tunnel dryer for a material which can be dried on trays in a layer 2 in. thick.

Data assumed to be given by Client.

Output required per hour (dry) ...	1,950 lb.
Weight of material per square foot, 2 in. thick (wet)	12 lb.
Weight of material per square foot, 2 in. thick (dry)	9·65 lb.
Maximum permissible temperature	170 deg. F.
Time required to dry a batch ...	8 hours

Temperature Range in Dryer.—Let the selected temperature range in dryer be 170 deg. to 90 deg.

Transportation.—Material to be carried on small bogie trucks, each 6 ft. 6 in. overall by 40 in. wide, holding 18 trays of sheet metal each 3 ft. by 3 ft. by 2½ in. deep.

	Lb.
Weight of one truck load, wet = 18 × 9 × 12... ...	1,950
Weight of one truck load, dry = 18 × 9 × 9·65 ...	1,560
Weight of moisture per truck ...	390
Assume weight of truck with trays empty	600 lb.

Rate of Removal of Trucks from Dryer.

Number of trucks to be removed dry per hour—

$$= \frac{\text{Output required per hour}}{\text{Weight dry, per truck}}$$

$$= \frac{1,950}{1,560} = 1{\cdot}25$$

That is, one truck to be removed (and another put in at wet end) every

$$\frac{1}{1{\cdot}25} \times 60 = 48 \text{ minutes.}$$

Number of Trucks Continuously in Dryer.

$$\frac{\text{Time to dry materials in minutes}}{\text{Rate of removal of trucks in minutes.}}$$

$$= \frac{8 \times 60}{48} = \frac{480}{48} = 10$$

Length of Tunnel.—Each truck is 6 ft. 6 in. overall, therefore length of tunnel = 10 × 6·5 = 65 ft., say 66 ft. with clearance at ends.

Width of Tunnel.—Trucks 40 in. wide, say, tunnel has 4 in. clearance each side, or 4 ft. wide.

Height of Tunnel.—Trucks carry nine trays high at 2½ in. per tray and 2½ in. clearance between trays, say = 42½ in., plus height of wheels, &c., and clearance at top, say, total = 51 in., or 4·25 ft.

Dimensions of Tunnel.—66 ft. long by 4 ft. wide by 4·25 ft. high. Having decided on the dimensions of the dryer, the heat required per hour is calculated as follows :—

1·25 trucks per hour :

Material of trucks =	600 × 1·25 =	750 lb.
Dry material	= 1,560 × 1·25 =	1,950 lb.
Moisture	= 390 × 1·25 =	487 lb.

Assume temperature of atmosphere 50 deg.

Heat Required per Hour.—(1) Heating trucks : Specific heat, wrought iron = 0·114

B.Th.U. per hour = 750 × (170 − 50) × 0·114 = 10,250

(2) Heating dry material : Specific heat, say, 0·2

B.Th.U. per hour = 1,950 × (170 − 50) × 0·2 = 47,000.

(3) Evaporating moisture at 1,100 B.Th.U. per pound.

B.Th.U. per hour = 487 × 1,100 = 536,000.

(4) Radiation from walls of dryer :—

Total surface, internal = 858 sq. ft.
Coefficient transmission = 0·269 (say)

$$\text{Mean internal temperature} = \frac{170 + 90}{2} = 130 \text{ deg.}$$

External temperature = 50 deg.
Mean temperature difference = 80 deg.
B.Th.U. per hour = Surface, square feet × Mean temperature difference × Coefficient transmission

= 858 × 80 × 0·269 = 18,400.

(NOTE.—If roof is of different construction from walls, its heat loss must be calculated separately with correct coefficient.)

(5) Leakage at doors : This is most difficult to estimate accurately. It may be assumed that all the air delivered to the plant leaves by the doors when these are opened to admit a truck at one end and to discharge a truck at the other end. At this stage, however, we do not know the weight of air to be supplied and an approximation must be made.

For all ranges of temperature in the list given, the leakage loss in B.Th.U. per hour may be approximated from :—

Pounds moisture per hour × Number of trucks to be removed per hour from each tunnel × 165

∴ B.Th.U. per hour = 487 × 1·25 × 165
= 100,000.

Summary of Heat absorbed in Dryer—B.Th.U. per hour.

Heating trucks	10,250
Heating material	47,000
Evaporating water	536,000
Radiation	18,400
Leakage	100,000
Total	711,650

Pounds Air, per Hour.—This heat must be given out by the air supplied when cooling from 170 deg. to 90 deg. i.e., 80 deg. fall in temperature.

Pounds of air per hour—

$$\frac{\text{B.Th.U. absorbed in dryer}}{\text{Temperature drop in dryer} \times \text{Specific heat of air}}$$

$$= \frac{711650}{80 \times 0.24} = 37,000$$

Total B.Th.U. per Hour in Air at Inlet.—The air to be supplied is to be heated from 50 deg. atmospheric temperature to 170 deg.

B.Th.U. per hour = 37,000 × (170 − 50) × 0·24 = 1,068,000.

B.Th.U. per Hour Loss in Exhaust Air.—The difference between the total B.Th.U. per hour and the B.Th.U. per hour absorbed in dryer is the heat lost in exhaust. This equals 356,350, or 33·4 per cent. of the total heat supplied.

Efficiency of Dryer.—

$$\frac{\text{Heat required to evaporate moisture} \times 100}{\text{Total heat in air at inlet}}$$

$$= \frac{536,000 \times 100}{1,068,000} = 50{\cdot}25 \text{ per cent.}$$

Percentage Saturation at Outlet.—Weight of moisture evaporated per hour in grains :—

= 487 × 7,000 = 3,409,000

Grains moisture absorbed in dryer per pound of air :

$$= \frac{3,409,000}{37,000} = 92$$

But each pound of air at inlet to dryer already carried 53 grains (saturated air at 50 deg. F.).

∴ Total grains per pound at outlet = 92 + 53 = 145.

And as from Table I, saturated air at 90 deg. F., can hold 218 grains moisture per pound :

Percentage saturation at outlet—

$$= \frac{145 \times 100}{218} = 66{\cdot}5 \text{ per cent.}$$

Approximating the Air Required.—The amount of air to be supplied to a tunnel dryer may be rapidly calculated for average conditions by the use of Table IV. This table has been made up on the lines of the previous calculations and allowance made for average radiation, leakage, &c. The outlet air is assumed to be 66 per cent. saturated with atmosphere completely saturated.

For example, suppose we require to evaporate 500 lb. moisture per hour in a dryer of average construction with a maximum temperature at dryer air inlet of 140 deg. F. :—

TABLE IV.

Inlet Temperature to Dryer.	Pounds Air to Supply to Dryer, per Lb. Moisture.	Pounds Live Steam to Heater, per Lb. Moisture.
70	1,000	5·4
80	460	3·7
90	305	3·3
100	230	3·0
110	180	2·85
120	150	2·75
130	125	2·65
140	110	2·6
150	100	2·58
160	90	2·55
170	80	2·53
180	75	2·50
190	65	2·49
200	60	2·42

The air required in pounds per hour, 500 × 110 = 55,000.
Pounds per minute, 917.
One pound of saturated air at 50 deg. occupies 12·9 cub. ft.

∴ Cubic feet of air per minute = 917 × 12·9 = 11,800.

It will be observed from Table IV that, as the initial temperature to dryer is increased, the weight of air required for a given evaporation rapidly falls and the efficiency of the dryer increases, less steam being necessary to be supplied to heater per pound of moisture evaporated.

Re-circulation of Air.—A well-insulated return duct should be provided from the air outlet end of dryer to fan room in order that air may be re-circulated in cold weather. The air heater may then be designed to raise the air from 50 deg. F. to the required inlet temperature, as in cold weather the final temperature of air from heater can be maintained by re-circulation of a part of the exhaust air. When the atmospheric temperature is 32 deg. F., about one-third of the exhaust air can be re-circulated as the cold atmospheric air even if saturated will only contain 26·5 grains moisture per pound and may therefore be mixed with exhaust air, thus maintaining the original moisture conditions at inlet and outlet of dryer.

Exhaust Steam for Heaters.—In a large drying plant it is advisable to instal an engine-driven fan, the exhaust steam from engine being utilised in the coils of the air heater. For an average high-speed engine as used for drying plants, an allowance of 50 lb. of steam per brake horse-power may be assumed. This figure is probably higher than one would expect, but is based on experience and tests of good engines of this class. The maximum air temperature obtainable with exhaust steam only on a heater is about 150 deg. to 160 deg. F., and if higher temperature is required, the exhaust heater must be supplemented by one or two sections supplied with live steam. The exhaust steam sections come first in the direction of the air travel through heater.

Air Supply to Compartment Dryers.—Similar methods of calculation to those already described may be employed, but it should be noted that it is usually impossible to get the air up to 66 per cent. outlet saturation without the use of re-circulating ducts, or without a circulation of the air inside the dryer caused by special internal fans. The air outlets must be very carefully arranged so that all the air must pass over the material to be dried without short-circuiting. It is advisable to calculate

TABLE V.

Inlet Air, Deg. F.	Outlet Air, Deg. F.	Pounds of Air per Lb. Moisture Evaporated.
90	77	450
100	80	290
110	83	220
120	85	170
130	88	140
140	90	120
150	92	110
160	94	100
170	96	90
180	98	80

5,000-KILOWATT BRUSH-LJUNGSTRÖM STEAM TURBINE.

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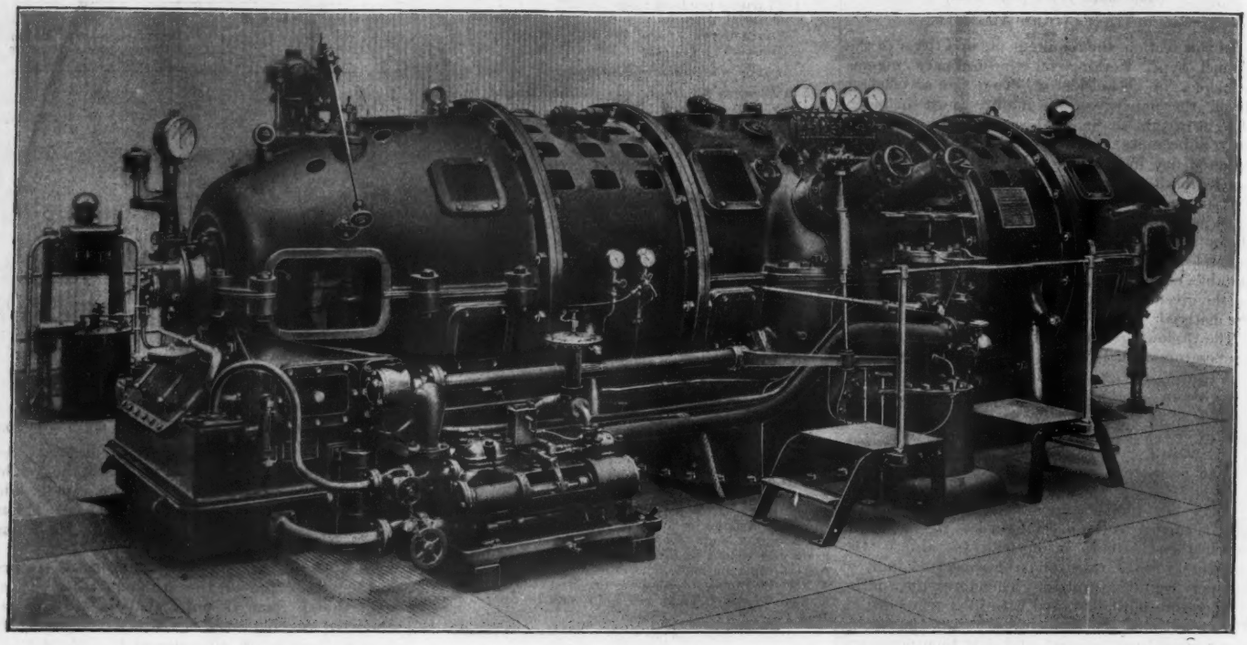


FIG. 1.

the air supply on a basis of 50 per cent. outlet saturation, with no air re-circulated and with atmosphere completely saturated. Table V is made up on these lines for average conditions of dryer construction. The efficiency may be increased in operation by re-circulation of a part of the exhaust air until a saturation of 66 per cent. is reached.

TABLE VI.

Material.	Room Temperature.	Time to dry.
	Mean ° F.	Hours.
Stains and varnish (caskets, pianos, &c.)	110	7
Shirts, flannels, &c. ... In drying machine with air circulated internally	120	¼
Blankets ...	120	¾
Cement sacks, on drying horses ...	120	1
Candied peel, on trays	165	2
Potatoes (steamed), on trays	170	6½
Cabbage and carrots (raw)	140	4½
Apples (sliced) (raw) on trays	175	6½
Hops, on floor in usual kiln	130	12
Retted flax on racks, lightly spread ...	120	10
Leaf tobacco on racks, lightly spread..	135	12
Stem tobacco	180	12
Cinematograph films, on wooden drums	80	¼
Millboard sheets, hung from clips ...	95	10
Ramie fibre, on perforated table ...	140	10
Earthenware plates, in revolving stove	110	8
Basils and skivers, on frames	75	48
Heavy hides from liquors, 1st ...	atmospheric	100 to 200
Heavy hides from liquors, on poles ... ... 2nd ...	70	72
Bone glue (thin sheets), 1st ...	70	100 to 124
Bone glue (thin sheets), on wire trays ... ... 2nd ...	80	100 to 124
Wool after scouring, on perforated floor	150	4
Toilet soap in ribbons (Cressonnieres' Patent)	90	½
Hanks, hung on poles	120	2
1½-in. oak or hardwood, piled in stacks	90 to 125	20 days of 10 hours.
2-in. to 3-in. oak or hardwood, piled in stacks	90 to 125	3 to 4 weeks.
The following are in tunnel dryers :—	Tunnel inlet.	Hours to dry.
Common bricks of easy-drying clay, on trucks	170	30
1-in. air-dried, soft woods, piled on trucks	175	72
1-in. green soft woods, piled on trucks	175	120
Casein, on trays	140	8

Practical Results.—As a rough guide the data given in Table VI will be of value. It is impossible to extend the list or to specify the details of each case more fully in the space available. All the figures refer to good modern plant of average construction, and in the cases of the tunnel dryers they are of the usual inverse type.

Low-Temperature Drying.—For certain materials such as gelatine, fish, &c., the air must be supplied at practically summer atmospheric temperature. From Table IV it will be noted that a very large quantity of air must be passed through the dryer and this in industrial districts may introduce considerable dust which might be a serious matter. It may therefore be necessary to wash the air in an ordinary air washer such as is now used for public buildings. This has the disadvantage that the air will leave the washer very nearly saturated as compared with the average condition of about 66 per cent. in summer weather. However, the difficulty may be overcome by the use of calcium chloride solution in the washer, which reduces the initial moisture in the air by absorption. Average summer air at 70 deg. F. would contain about 72 grains moisture per pound when unwashed. If put through an ordinary washer the moisture content might reach 109 grains per pound. The effect of washing with various strengths of solution of calcium chloride is as follows :—

Percentage Strength of Solution.	Grains of Moisture, per Lb. of Air.
20	81
30	65
40	41

The solution of calcium chloride is afterwards regenerated by the application of heat, and it is found that this method is more economical than refrigeration for reducing the initial moisture in air when large volumes are required to be used in the dryer.

5,000-KILOWATT BRUSH-LJUNGSTRÖM STEAM TURBINE.

IN our issue of April 12, 1912, appeared the first public description of the Ljungström steam turbine. The unit then described was rated at 1,000-kw. and was proved by independent and thoroughly reliable tests to be markedly more efficient than any other turbine of equal rating constructed up to that date. As is well known, for equal efficiency a large turbine and a small turbine should be designed to have the same ratio of blade speed to steam speed. For reasons which were mainly commercial, turbine builders up to 1912 had found it impractical to attain with small turbines as high an efficiency as was readily achieved with large units. Other things being equal, the efficiency of a steam turbine depends upon a certain co-efficient K, which is defined by the relation

$$K = n \left(\frac{d}{10}\right)^2 \left(\frac{\text{R.P.M.}}{100}\right)^2$$

where n denotes the number of moving rows of blade and d the mean diameter of the blade path in inches. Within practical limits the efficiency of a turbine increases with an increase in K, the rate of improvement being rapid at first and then slowing down. For a specified speed of rotation, however, the weight and cost of a turbine increases in nearly direct proportion to the value of K, and in the case of turbines of small output the gain in steam economy due to an increase of K was found to be disproportionate to the corresponding increase in the cost of construction. Hence it was customary to adopt much smaller values of K for small turbines than for large ones.

Probably many engineers, prior to Mr. Birger Ljungström, had realised that by replacing the fixed casing and single rotor of an ordinary turbine by two rotors turning in opposite directions, the effective value of the R.P.M. in the formula for K would be doubled, and the size and weight necessary for a given efficiency reduced to one-fourth of the value otherwise requisite.

The mechanical difficulties of realising such a concept in practical form were, however, extraordinarily great, and to most must have appeared insuperable. The surmounting of them by Mr. Ljungström involved engineering ability and scientific knowledge of a very high order. It was not merely a new machine that Mr. Ljungström designed, but he showed how it could be constructed, devising to this end a whole series of workshop operations of a novel and highly-ingenious character. But for these remarkable innovations in shop practice, the embodiment in a commercially practical form of his "double rotation" turbine might have been postponed almost indefinitely.

The Brush Electrical Engineering Company, Limited, of the Falcon Works, Loughborough, are

the licencees in this country for the Ljungström turbine. Of these they have now constructed and erected a large number, which have given very satisfactory service.

The original 1,000-kw. unit which we described in 1912 was soon followed by larger units and in 1916 there was installed one of 5,000–7,000-kw. output at the Willesden Station of the North Metropolitan Electric Power Supply Company.

At that date high vacua were somewhat rare in turbine condensers, but to-day a vacuum of 29·1 in. is very widely accepted as the standard. An increase of vacuum from 28 in. to this figure, means that with the higher vacuum the specific volume of the steam as it passes through the last row of blading is practically twice what it is at the lower figure, and all turbine designers have been faced with the problem of producing a steam way sufficiently ample to reduce "leaving losses" to a reasonable percentage.

The Ljungström turbine has also had to meet this difficulty, and on Plate XXXIV and on pages 542 to 544 we give illustrations of a 5,000-kw. Brush-Ljungström turbine in which the problem has been solved by fitting radial blades to the periphery of the Ljungström rotors.

The pattern illustrated is rated by the builders either as capable of generating continuously 5,000 kw. to 5,500 kw., with an overload capacity of 25 per cent. maintainable for two hours, or alternatively the unit may, with slight modifications, be operated under a continuous full load of 7,000 kw.

Fig. 1, page 542, shows a general view of the turbine and generators complete. The turbine is situated between the two generators, and is mounted directly on the surface condenser which constitutes the only bed plate used. The two generators project cantilever fashion from the turbine casing, to which they are bolted. The weight of these generators is, however, carried almost completely by springs, which in their turn are supported by the condenser shell.

A longitudinal view of the unit, for the main part in section, is reproduced in Fig. 2, Plate XXXIV, whilst Fig. 3 shows a half longitudinal section through the blading, and Figs. 5 and 8 other cross sections. In Fig. 2 the turbine proper is comprised entirely between the two-flanges lettered *a a*, and it can, when desired, be lifted out bodily as a unit complete in itself without disturbing any steam connection.

A section through the upper half of the turbine is shown in Fig. 3, but it should be added that this is in some particulars a bastard section. It shows, in fact, the steam pipe *b*, which connects the turbine steam chest with the governor-valve, but these steam pipes are really situated in the lower half of the turbine, as is indicated in Fig. 2, on Plate XXXIV. The actual position of the overload valve *c* is also misrepresented, as although this is situated at the top half of the turbine, its true position is as represented in Figs. 10 and 11, subjoined.

The two steam rotors are denoted by *h* and h^1 respectively. The steam enters between the rotors near the centre and flows radially to their circumference, passing through the blading shown. This blading was described in detail in our previous article, as also the methods used in its manufacture, so we need not refer to it more particularly here. The original Ljungström turbine terminated in the row of blades lettered *m*, but with the high vacua now specified it was impracticable to make such blading long enough to provide the requisite steam way. Hence, in the new model, after leaving *m*, the steam is passed through the fixed guide blades *j*, which direct it on to impulse blading *i*, which is, it will be seen, mounted radially on the periphery of the rotors. This last stage of the turbine provides, it will be seen, a "double flow," giving an ample steam way and moderate "leaving losses," the axial velocity of the steam on leaving the last row of blades being from 500 to 550 ft. per second. The steam chest *e* is machined out of a solid steel forging and is carried from the flanges *a a* by means of the dumb-bell expansion rings shown at *d d*. These enable the components to adjust themselves, without heavy strain to changes of temperature. Similar dumb-bell rings connect to the steam chests *e e*, the stationery labyrinth discs *f f*, which form one-half of the dummies which prevent serious leakage from the steam chest to the exhaust space *g*. These dummies were fully described in our previous articles, to which we have already referred.

Each of the rotors *h* and h^1 is built up of three main components exclusive of the labyrinth discs. These three sections are also connected to each other by dumb-bell expansion rings. The innermost section of each rotor fits on to a conical seat *p* or p^1, which can be bolted to the corresponding generator shaft *s* or s^1 by a ring of bolts one of which is shown to the left at *q*.

At the corresponding position on the opposite side of Fig. 3 is shown a starting bolt *k* which, when the turbine is to be dismantled, is used to bring out of their recesses the registers at *r* or r^1. In effecting this operation, the rotor of one of the generators is displaced for a short distance axially. The flanges *a a* are, of course, free once the top cover has been removed, and once the registers are clear, the whole of the turbine can be lifted out of place as the steam pipe joints are merely telescopic. Special tackle is provided for this operation to which we shall recur later.

Steam from the steam chest *e* gets access to the blading through a series of openings *n n* machined in the innermost sections of the rotors. In passing between the rotors, the steam produces a heavy axial thrust on each, and this thrust is balanced by the counter pressure of the steam which is simultaneously leaking through the dummies *f*. Any residual thrust is carried by the Michell thrust bearings shown at the end of the generator shafts in Fig. 2. As originally constructed, oil-filled dashpots were provided for this purpose, but whilst quite effective, they required careful attention to prevent leakage of oil or the entrance of air.

The glands *w w*, where the rotor shafts pass through the fixed steam chest have to be packed against high pressures. They were described in detail in the article already cited. In essentials, the design remains unaltered, but as now constructed, the escaping steam, as it leaves the last constriction of the gland, is caused to draw in air, by an injector action, from the spaces *t t*; and to discharge it into the spaces *r r*, which are connected by pipes, one of which is indicated at *o* in Fig. 3, and is also shown in its true relative position in Fig. 9, annexed. This pipe leads away the mixture of steam and air to a separate condenser. The object of this arrangement is to prevent the possibility of steam leaking into the space *t*, where it might condense and fall into the oil, whilst further steam might pass beyond the bearings to the generator windings.

Owing to the gland steam being thus diluted with a large admixture of air, it cannot be turned into the main condenser, and a small auxiliary condenser has to be provided accordingly. The main condensate from the turbine passes through the tubes of this condenser, thus recovering the heat from the gland steam. Repeated measurements have shown that this gland leakage amounts to from ¾ per cent. to 1 per cent. of the total steam passing through the blades.

The exciter for the generator is fitted, it will be seen, on the shaft of the generator shown to the

Fig. 8.

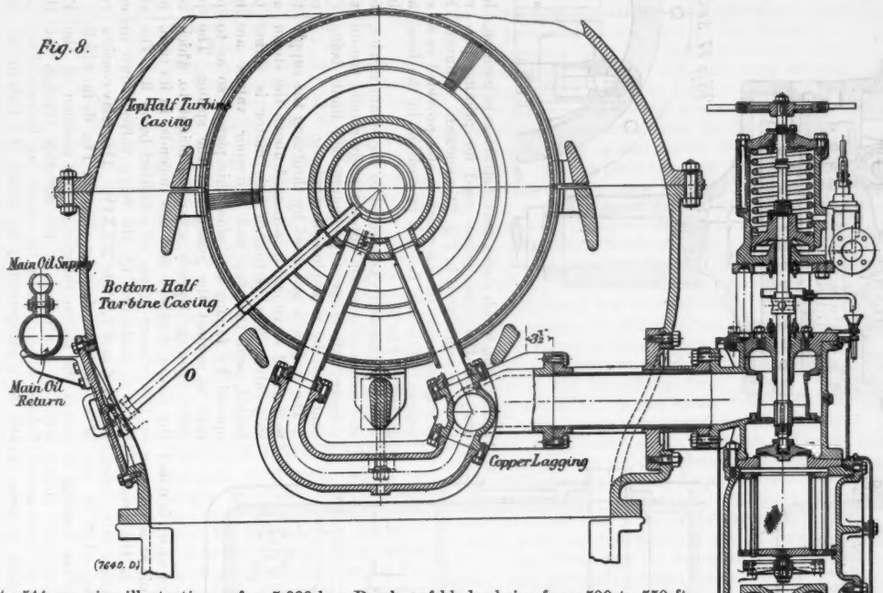
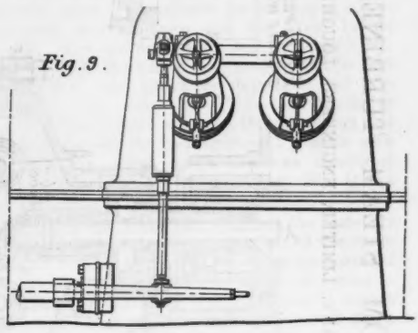


Fig. 9.



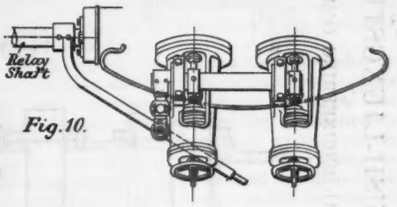
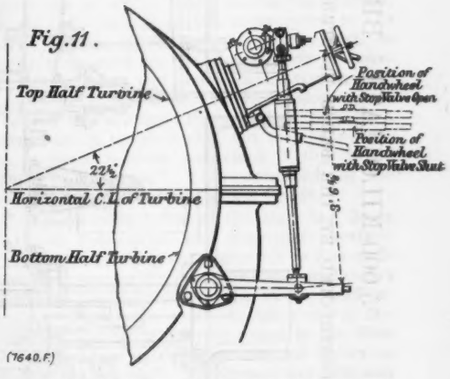


Fig. 10.

Fig. 11.



5,000-KILOWATT BRUSH-LJUNGSTRÖM STEAM TURBINE.

CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, ENGINEERS, LOUGHBOROUGH.

Fig. 12.

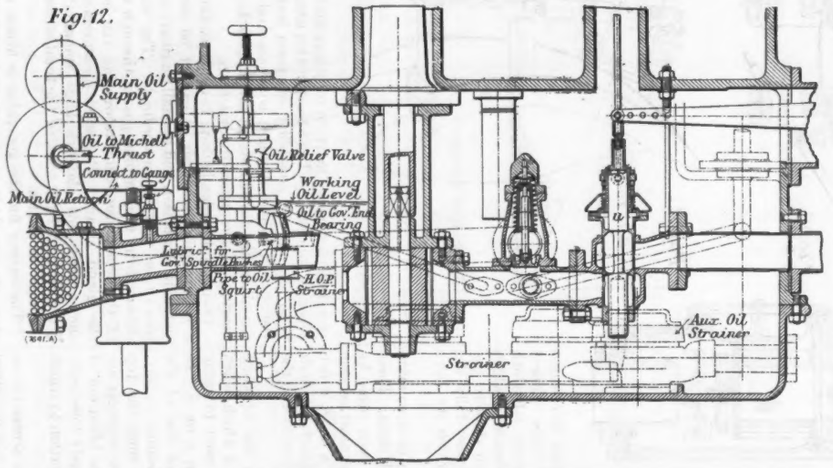


Fig. 13.

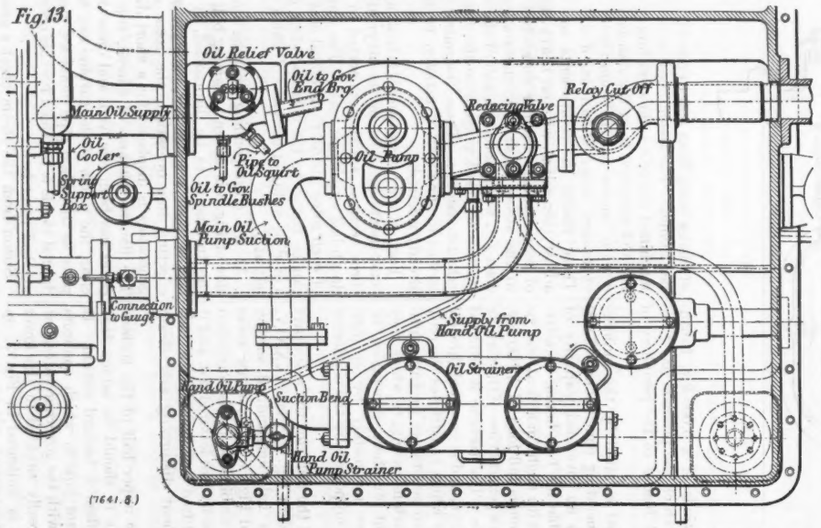


Fig. 14.

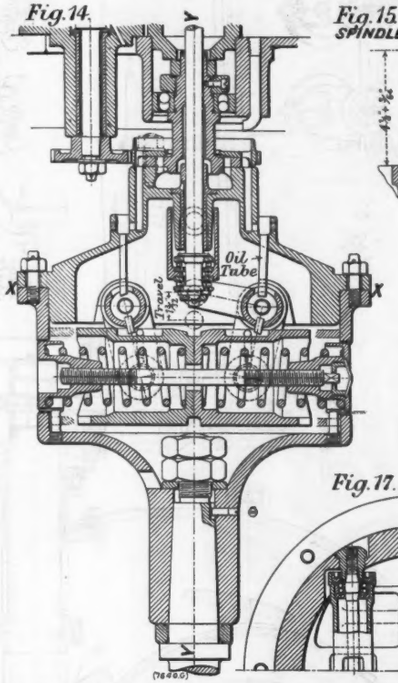


Fig. 15. POSITION OF ACTUATING SPINDLE WHEN GOVERNOR IS SET.

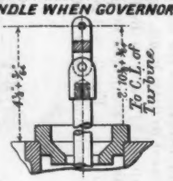


Fig. 16. SECTION Y.Y.

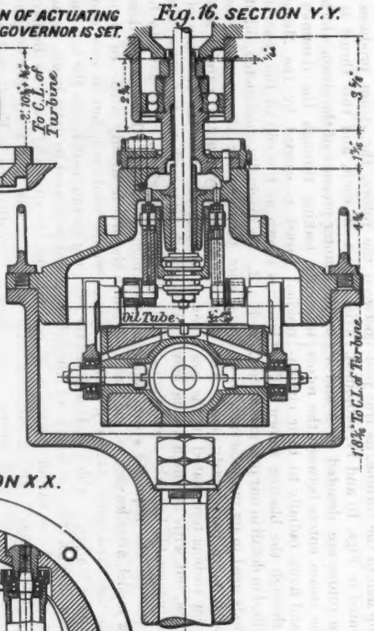
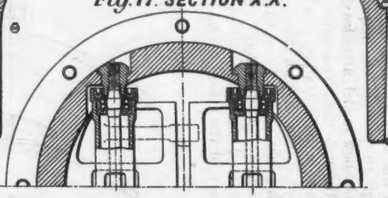


Fig. 17. SECTION X.X.



right in Fig. 2, whilst the oil pumps and main governor occupy a corresponding position on the left. A section through the governor is shown in Fig. 5, Plate XXXIV. The governor spindle is, it will be seen, driven by spiral gearing from the generator shaft. At its upper end it carries the main governor to which we shall refer in more detail later, whilst an oil pump of the gear type is fitted at the lower end of the spindle. This pump is completely immersed in the oil, the normal level of which is noted on the drawing. It delivers the oil at a pressure of 30 lb. per square inch, which is the pressure needed to operate the stop and governor valve relay. For lubrication purposes a pressure of 5 lb. per square inch suffices, and the oil for the bearings is accordingly drawn off by the reducing valve shown in Fig. 5. The details are shown to a somewhat larger scale in Fig. 12, above, whilst a plan of the oil well, which shows the oil strainers in position, and also the hand pump used for priming purposes, is reproduced in Fig. 13, annexed. A direct-acting steam-driven oil pump is also provided as a reserve. This can be seen in position in the foreground of Fig. 1.

It is permanently connected to the steam service, and comes into action automatically should the oil pressure fall below a pre-determined limit, being controlled by a diaphragm regulator.

The turbine is governed by throttling the supply to a small servo-motor, arranged above the steam stop-valve. The piston of this motor is spring loaded, and the stop and governor valves are opened by forcing oil below this piston, so as to raise it against the pressure of the spring. The valve opening depends upon the height to which the piston is raised, and this depends, in its turn, on the pressure of the oil admitted below it. The latter is controlled by the relay valve shown in Figs. 5, 6 and 7, Plate XXXIV. This relay consists of a movable sleeve v, seen in Fig. 6, in which moves the piston valve w. The position of the latter is controlled by the governor through the linkage shown, whilst the sleeve can be moved up and down independently by means of a fork in the lever x (Fig. 5), which is keyed to a lay shaft running along the front of the turbine as shown in Fig. 1, and which follows the movement of the valve spindle as indicated more or less diagrammatically at y, Fig. 5. In this way the requisite "overtaking" motion is provided for. If the main governor comes into action, it displaces the piston valve w, thus allowing oil to pass through the openings shown in the sleeve from the lower part of the casing z to the upper part, which opens directly into the pipe leading to the relay. The relay piston accordingly moves the valve spindle, and the latter by means of the fork moves the sleeve v so as to bring it, relatively to the piston valve, w into the position indicated in Fig. 7, which shows the relative position of the two when the speed of the turbine is steady. The running speed can be adjusted 5 per cent. up or down by means of the hand-gear shown, and a small electric motor shown to the left enables the same operation to be effected from the switch board.

Further details of the governor are illustrated in Figs. 14 to 17, annexed. The noticeable point is that no dash pot is provided to stop hunting, as it has been found unnecessary, if friction be adequately eliminated. To this end ball bearings have been

freely adopted and very ample and complete lubrication provided for. The builders state that this is so effective that in certain cases the rise in speed between full load and no load has been under 1 per cent.

(To be continued.)

THE FIRST TRANSATLANTIC MAIL SERVICE.

By A. W. JOHNS, C.B.E., R.C.N.C., M.I.N.A.

THE first regular Transatlantic mail and passenger service ran between England and the West Indian Islands and was inaugurated in 1702, the year in which Queen Anne ascended the Throne.

This service was suggested, organised and for some years managed by Edward Dummer, who had previously been a naval architect in the Government service. In 1686 he was serving as one of the three assistants to the master shipwright—Robert Lee—at Chatham Dockyard, and in that year Samuel Pepys, reporting to the King on the shipbuilders then engaged in the Royal and merchants' yards, described Dummer as "an ingenious young man, but said rarely to have handled a tool in his life; a mere draughtsman." The report was not altogether an unbiased one, for its object was to convince the King that Sir Anthony Deane, formerly master shipwright and commissioner, but then retired, and who was a close friend and at one time fellow-prisoner of Pepys in the Tower, was the one and only person who could be entrusted with the highly responsible task of rebuilding the Navy and reorganising the Royal Dockyards then in contemplation. The report of Pepys succeeded in its purpose, but, in spite of his not too favourable report on Edward Dummer, that officer was promoted to the important post of Surveyor of the Navy and member of the Navy Board when Sir John Tippetts, who had held that post from 1672, died in 1693. The appointment of an assistant master shipwright, as Dummer then was, to such a position was remarkable, for Tippetts before, and all surveyors since, had to serve many years as master shipwrights before promotion.

Dummer held the post until 1699, when, on account of some charges of bribery being brought against him by a shipbuilder named Finch, he was suspended from duty. A legal action followed, Dummer being the plaintiff, and, as Finch could bring no evidence to substantiate his charges, the plaintiff was awarded 500*l.* damages. Dummer resigned his post shortly after the conclusion of the legal proceedings, and was succeeded by Daniel Furzer, master shipwright of Sheerness Dockyard.

The official State records between 1696 and 1702 are not yet published, and Dummer's public activities, if there were any, are unknown between 1699 and 1702. In the latter year he is first mentioned as a petitioner for the payment of his salary during the period of his suspension from duty as surveyor. The matter was investigated by the legal authorities, with the result that the Queen granted his petition.

A month later—May, 1702—in a letter to the Secretary of State, Lord Nottingham, Dummer describes himself as an "adventurer" of four vessels, a very suitable and expressive word in those times, but now replaced by the more prosaic "shipowner." These four vessels traded between London and Holland, were in great request by merchants, and, according to Dummer, had done much to encourage trade between the two countries. War had been declared against France and Spain on May 2, 1702, and on the same day an embargo had been placed on all ships in port. This was the reason for Dummer's letter to Lord Nottingham. He proceeded to point out the crews of his vessels were protected by the Lord High Admiral against impressment into H.M. service, but that, whilst the vessels were lying idle under the embargo, the wages of the officers and men had to be paid, and this was proving a great burden to him. Finally, Dummer asked for the removal of the embargo from his ships, a request which was granted shortly after. Later in the same month he wrote to Lord Nottingham suggesting the Transatlantic mail service, and enclosing his scheme for its operation.

At that time, or, rather, before the outbreak of war, mail or packet services were running from England to the Continent of Europe by three routes. The carriage of mails between Dover and Calais was of long standing, whilst that between Harwich and Holland had been instituted in Charles II's reign. The third service, started in 1688, was between Falmouth and Corunna, in Spain. In time of war with the country in which the terminal port was situated, the service had to be discontinued or diverted to a neutral port, as, for example, during the wars with Spain, the Falmouth packets sailed to Lisbon.

The vessels employed on these services were relatively small, but were good sailers and armed with ten or twelve guns for defence against the numerous privateers infesting the seas even in peace time, and against the armed naval forces of the enemy when this country was at war. Often they had to fight on their way, and at times were captured. The services were under the control of the Post Office, their officers had the King's Commission, and their crews were protected from impressment.

In 1694, at King William's suggestion, a new type of packet boat was tried on the Harwich to Holland service. This type had less freeboard than was usual at the time, and the guns were omitted, the King's object being to improve the stability and thereby increase the sail area and speed. The improved speed was considered by the King to be a better protection against hostile ships than a gun armament. The experiment was not a success. The ships proved extremely wet, the officers and men had to suffer great discomfort thereby, and experience soon showed that, on the appearance of a suspicious craft to windward, the packet boat, in the absence of guns for defence, returned to port. Delay in the mails resulted, and the armed type hitherto employed was substituted.

For the carriage of official letters overseas or the despatch of orders to the admirals at sea, advantage was taken of any warship which might be proceeding on service in the desired direction. If this means were not available, special naval vessels, termed "advice boats," were despatched for the purpose. These were small vessels similar to the packet boats, and carried private correspondence in addition to the more important official despatches for which they were primarily despatched. As these naval vessels were only used when the service of the State required, and were then generally sent at very short notice, they could not be depended upon for a regular and private correspondence.

In his letter of May 24, 1702, to Lord Nottingham, Edward Dummer described his proposals for "a scheme of foreign advice" between England and the West Indian islands. He proposed to use four vessels, each of 130 tons burthen, which were to run regularly at one-month intervals, calling at Barbadoes, Antigua, Montserrat, Nevis and Jamaica, returning from the last island direct to England. Each was to stay four, three, three, three and eight days respectively at the five islands, to allow answers to the more urgent letters to be brought back by the same boat. A schedule of voyages for the four vessels was outlined, by which one starting in January would return in April and proceed on its second voyage in May, the other three starting respectively in February, March and April. Dummer estimated the voyage out and home would take ninety days. "By this means," wrote he, "I propose to make all intelligence by sea less precarious and more expeditious than now is. This continual going out and returning will answer all the needs of State and trade and conduce to the public interest between this country and the West Indian Islands in peace and war."

On May 27 Lord Nottingham forwarded Dummer's proposals to the Council of Trade and Plantations, a body corresponding to the present Colonial Office, for their consideration and report. The Council interviewed Dummer, discussed the whole matter with him, and on June 22 informed Lord Nottingham they were of opinion Mr. Dummer's proposals would be of great use to Her Majesty's Service and of very great advantage to the plantation trade. They considered, however, the time allowed for the whole voyage out and home—ninety days—was insufficient. Further than this, it was thought that, as Jamaica was so far west of the other islands at which it was proposed to call, and had a very much greater trade, an independent service should be instituted for it. A similar provision was also considered necessary for the plantations on the Continent, *i.e.*, what are now the Eastern of the United States of America. Each of these services would require four vessels, but, if this proved too burdensome for Mr. Dummer, they suggested a smaller number of vessels, with a less frequent service than monthly. Finally, they proposed Falmouth as the terminal port and that the charges for the mails should be settled by the Post Office and the Navy Board.

In the meantime, the proposals had been sent to Mr. Burchett, Secretary to the Admiralty, for the consideration of the Lord High Admiral, Prince George of Denmark, and a Council appointed to assist him in his duties.

A week after the Council of Trade, &c., had replied, and before the Admiralty reported, Lord Nottingham informed the former: "Her Majesty has ordered an agreement to be made with Mr. Dummer upon his proposals for settling a correspondence with Jamaica and the West Indian Islands. You are to consider and settle with Mr. Dummer and report how the voyages shall be best made and to what places the ships shall go." On the same day—June 30, 1702—the Admiralty was made acquainted with the Queen's orders and directed to make the best agreement possible with Mr. Dummer. Both communications concluded with, "Expedition is necessary, as the Queen desires no time to be lost in sending ships."

On July 3 the Admiralty informed the Secretary of State that an order had been given to the Navy Board to hire Mr. Dummer's vessels for the proposed service, but "as the service on which they were to be employed was remote from the Navy, it cannot be admitted that they are to be paid out of Navy funds." There was no objection, however, to the vessels being granted letters of marque, wearing the Queen's colours, or to the crews being protected from impressment.

A copy of the proposals was then forwarded to the Post Office and the Postmasters-General—there were then two—asked to report on them. On August 13 they replied, suggesting an alternative scheme, which, although, in their opinion, not so good as that of Mr. Dummer, would probably be very much cheaper. They assumed that despatches and letters of a higher nature would be sent by men-of-war or advice boats, as was the practice, leaving only matters of less consequence to the packet service. Their proposal was to hire, as might be required by the accumulation of correspondence, "good and nimble-sailing vessels, such as sloops and brigantines, as used by the Government in the last war, and never then found wanting. Such vessels were in the river now, but they—the Postmasters-General—could not state if this would always be the case." Their estimation of the charge of such a vessel was 150*l.* a voyage.

It appears evident that at this stage the Queen and Lord Nottingham were becoming impatient at the delay in settling the matter, for on August 20 orders were sent to the Post Office and the Prince's Council at the Admiralty. The former were informed, "The Queen desires to make use of Mr. Dummer's vessels for carrying letters to the West Indies. You are to consider rates for letters to and from the Islands." The Council was informed, "Mr. Dummer having received orders to prepare his vessels . . . the Queen desires protection given to such men as are necessary for the Service. As the Queen is to bear the charge of these ships and to have the profits which may be derived by their bringing passengers, or gold, silver and cochineal (the only things they are to be allowed to bring), the Navy Board are to consider what rates should be charged passengers or any of these things."

The Admiralty was also to report what sum of money should be impressed Mr. Dummer to enable him to fit out his vessels for the Queen's Service, pay wages to the crews and any other charges. Finally, they were to prepare a draft of such articles and instructions as they considered necessary, bearing in mind that Mr. Dummer had to give

an account from time to time of all his expenses and profits from all sources.

After his interviews with the Council of Trade in June, Dummer re-drafted his scheme, and allowed a longer time for the voyage, cutting down the total number of days of stay at the various islands from 21 days to 11, the whole voyage out and home being then given as 100 days. To the suggestion of the Council that Jamaica should be left out of the service, he replied that, if this were done, he would withdraw his scheme, but if the Queen would hire his vessels, pay the men's wages, and make good all wear and tear, the ships could be sent as the Council of Trade desired. This, however, was not accepted, and the original scheme as to the islands to be called at was adhered to, except that St. Christopher's was added.

No particulars are given as to the terms of Dummer's contract or as to the charges for letters and the gold, silver or cochineal they were allowed to carry. It is stated, however, that passengers were charged 12*l.* for the voyage Jamaica to England, 2*l.* 10*s.* between Barbadoes and Antigua, and 4*l.* between the other islands and Jamaica.

In September, 1702, all preliminary arrangements having been satisfactorily settled, preparations were made for the departure of the first vessel on the service. On September 16 instructions were sent to the Post Office "to publish the design of Mr. Dummer's vessel to the West Indies, in such a manner as is usual and best, so that the merchants and people concerned may know of it." The Admiralty received directions to appraise the vessel and decide what colours she should wear; whilst Mr. Dummer was ordered to have his vessel at Portsmouth as soon as ready and to acquaint the Post Office when she would be there to enable the merchants' letters to be sent down.

On October 1 the Admiralty decided to grant the Queen's commissions to the commanding officers of the first two vessels, Captain Ralph Corbett, of the Bridgman, and Captain Richard Sympson, of the Mansbridge. Although the State records do not mention it, there is little doubt the commanders of the other vessels were granted the same privilege.

The first vessel, the Bridgman, sloop, started from the Needles on October 22, 1702. She carried letters and advertisements of the service from Mr. Dummer to the Assemblies of the various islands. The letters concluded, "The motions are determined to be very quick, because thereon depends the chief fruit to be reaped."

On February 15, 1703, Dummer reported to the Council of Trade the return of the Bridgman. Arriving at Barbadoes on November 18, she stayed three days, and reached Antigua on the 24th; stopping there one day, she reached Montserrat on the 26th; called at Nevis and St. Christopher's, leaving the latter on December 1, arriving at Jamaica on the 6th. She left Jamaica on December 15 and arrived at Falmouth on February 2. "The voyage," remarked Dummer, "has taken three months thirteen days, but the Captain thinks that, but for some interruption at Jamaica and a little difficulty with a privateer in the narrow of the Windward Passage, he would have made the voyage twelve days sooner. He has not lost a man. He was very diligently despatched at all the islands, save at Jamaica, where he was to clean, he spent more time than was allowed him, which was accidental. However, the alacrity of the people of all the islands in assisting his despatches according to his orders is a great demonstration of their satisfaction on this service, for, although his motion was so quick, yet he brought home 1,500 letters and the Dutch despatch from Curacoa."

There was a hitch in the despatch of the second vessel, and Dummer's report to the Post Office shows the difficulties the sailing ship had to contend with and at the same time one advantage of steam propulsion. "The Mansbridge," wrote Dummer, "sailed on November 15 from London to a place called Leape, on this side of Lymington, to be tallowed as was done to the Bridgman. The weather was stormy and delayed the work. When it was done I sailed her to Jack o' the Basket to take the first wind suitable for the channel course. Stormy weather came on on the 27th, and she returned under shelter of Hurst Castle. She put to sea again on the 1st, but returned to Jack o' the Basket on the 3rd owing to bad weather. She sailed on the 5th and, I hope got to the Start before the wind shifted on Sunday evening." Apparently Lord Nottingham was not advised as to the reasons for the delay in starting, for, on December 12, he directed Mr. Adin, Clerk of the Cheque at Plymouth, to examine the master's journal to ascertain why she delayed starting on her voyage for four weeks contrary to orders. After this delayed start the Mansbridge did well, making the round voyage in 92 days. The third vessel, the King William, started to schedule time and reached home in 107 days. The three vessels took, respectively, 28, 35 and 39 days for the voyage England to Barbadoes, and 49, 34 and 44 from Jamaica home. As either distance is approximately 4,000 miles, the 28 days taken by the Bridgman averages slightly over 140 miles a day, a very creditable performance in those times.

The fourth vessel—the Bridgewater—was unfortunate, being captured by a French privateer off Dungeness on her voyage around from London to Falmouth, from which she was to set out on January 28. No other ship being ready to take her place, the service was interrupted for a month.

After this the service proceeded regularly, and on November 17 Mr. Dummer reported on his twelve months' experience, giving the times of the round voyages of the seven ships which had completed them as 105, 92, 107, 114, 100, 100 and 103 days. He stated that, in accordance with many requests from the planters on the islands, he proposed to allow the vessels to make a longer stay, about a day extra, at each.

Two years later he forwarded another report, in which he gave the times taken by the vessels, and showed "he had fulfilled his undertaking to keep a monthly correspondence with vessels, each taking about 100 days, though at first it was thought impracticable by many of the ablest seamen in England."

Dummer's accounts of the sailings and arrivals of his vessels continue until the end of 1708, the date of the latest published extracts of the Colonial records. Many of the reports show that the service was not without exciting incidents. French warships were then very active in the West Indies, and privateers were numerous and daring. A planter at Antigua had written Dummer in June, 1703, as to the danger from privateers, and warning him there were so many about the islands that not one in three trading ships escaped them. On July 3, 1705, Dummer reported one of his vessels, the Cotton, sloop, sailing from Barbadoes to Antigua, after avoiding two privateers, had been captured by a third. He added that it was commonly reported there were 22 privateers at Martinico (Martinique). In August of the same year, in reporting the arrival of the "Six Islands," he stated she had been chased by several privateers west of Scilly. In October the Queen Anne, out and home in 105 days, had met extremely bad weather, lost two topmasts and the foremast, had to come home with jury foremast, "and in the Soundings was chased every day."

Besides the Bridgewater captured by the French off Dungeness, and the Cotton by privateers in the West Indies, the only other loss in the six years was the Barbadoes, which was wrecked on a coral shoal near Hineago Island, and afterwards plundered by pirates, who also captured two of her officers. The Governor of Jamaica, reporting on her loss, gave it as his opinion that the vessel was laden too deeply. Dummer, however, considered it due "entirely to the carelessness, want of conduct or courage in the seamen, for the vessels are of all other without exception, and will do as a man pleases. However, I am not discouraged, and these accidents show at the same time the means that will prevent them."

When the conditions prevailing at the time, and the size of the vessels employed on the service, are considered, Dummer suffered surprisingly small losses during the six years covered by the published records. England was at war with France and Spain during the whole time and, as we have seen privateers were active. The vessels proposed by Dummer in his original scheme, and presumably used, were of about 130 tons burthen, which, with the system of measurement for tonnage then in vogue, would represent a vessel of an overall length of about 75 ft. and a beam of 21 ft., a mere boat compared with the ships now engaged on a similar service. The records do not state the details of the instructions supplied to the commanding officers of the vessels, but one is clearly stated in the following report from Dummer in August, 1703: "The Mansbridge sloop arrived at Falmouth, out and home in 99 days. The master fell foul of a French vessel laden with salt for Newfoundland and has taken her, but left her in the sea. However, it is a positive breach of his instructions, and I shall remove him."

The service was found extremely useful by the Government authorities during the war, and intelligence of the movements and actions of the enemy forces in the West Indian Islands were promptly conveyed and reported by Dummer and his captains. Without such assistance the home authorities must have been at a serious loss in taking those steps which were necessary for the defence of the islands, and warships which could ill be spared would have had to be employed for conveying intelligence home from the naval and military commanders. On March 13 Dummer reported one of his ships just arrived had called at Jamaica on January 29, and found "Port Royal burnt by the French, all but the castle." On January 6, 1707, the Jamaica arrived home and reported the season very unhealthy, Commodore Kerr having lost 300 men by sickness, and the Jamaica herself 10 men on the voyage home. On March 5, 1708, Captain Button, of the King William packet, reported that he found, on his arrival at Barbadoes, 11,000 men, of whom 3,000 were disciplined negroes, armed and ready for an expected attack by the French.

As already mentioned, Dummer's vessel, the Bridgman, on her first voyage, brought home the Dutch official despatches from Curacoa, and there is little doubt further advantage was taken of the service for a correspondence between Holland and the Dutch West Indian possessions. In 1705 the Spanish in the islands, although we were at war with Spain, wished to avail themselves of the same means of communication with Europe, and Dummer applied for advice to Lord Nottingham as to the action desired. The Council of Trade and Plantations were consulted on the matter, and reported they saw no objection to the Spanish mails being carried by Mr. Dummer's service. They considered, however, the Governor of Jamaica should open all correspondence coming home and the Post Office all going out, "lest criminal correspondence be carried on on behalf of the French." Dummer's service thus proved useful to three nations.

Queen Anne evinced a more than ordinary interest in the enterprise of Dummer, and watched its progress. In October, 1705, Lord Nottingham informed the Council of Trade of the desire of her Majesty to have Newfoundland linked up with the West Indian packet service, and her wish that the Council should discuss the extension with Mr. Dummer. The latter, however, was not inclined to undertake this much longer and more hazardous voyage, and the project was dropped.

Dummer himself proposed to extend the service to the mainland, and the Governor of Maryland was directed by the Council of Trade to bring the proposal to the notice of the Colonial Assembly and ascertain if any assistance was likely to be given. In March, 1707, the Governor reported the intention of the Assembly to discuss it at the next meeting, "as I thought it advisable to see how far they would go to promote so good a design. I cannot say with any great expectations, considering how backward I find them in settling the posts." In the following June he reported, "Notwithstanding that we hear not from England in seven, eight or nine months during the war, the Assembly with the like reason that they might still continue irregular and gainsaying, rejected Mr. Dummer's proposal for more speedy advice and intelligence by way of his packet boats." From the latest of the published Colonial records it would appear that, after this refusal of help from the Maryland Assembly, Mr. Dummer was requested by the Council of Trade to forward fresh proposals for their consideration, but the result of this is not known.

Already, in 1703, and suggested by Dummer's West Indian service, a scheme for a direct mail service between England and New York had been

submitted to the Queen by Sir Jeffrey Jeffreys, a director of the East India Company. In February of that year he wrote, "Your Majesty has arranged a service of four packet boats to the West Indies, whereby frequent advices may be sent to and from those parts. The same method will be advisable in relation to communication with North America and New York, being the centre of those parts I propose to furnish your Majesty with two vessels suitable for that purpose." One vessel was to be armed with 12 guns, carry a crew of 40, and fitted with oars and strong fittings for winter service. The second was to have eight guns, a crew of 30, and to be ready two months after the first. The charges were 200*l.* and 150*l.* per month, but, as an alternative, if it were the Queen's pleasure, both would be of 150 tons, 14 guns and a crew of 40, and the hire for the two 350*l.* a month, 13 months in a year. They were to be allowed to carry passengers and a few goods for ballast, not exceeding 50 and 30 tons respectively for the two vessels of the first proposal. The vessels were to stay 30 days at New York, to allow letters to be delivered to New England, Virginia, Maryland and adjacent Colonies, and the answers collected. The round voyage was estimated to take five or six months, and the terminal port was to be Cowes.

This proposal was considered by the Council of State and Plantations, who suggested the stay at New York should be 20 to 25 days in summer and 30 to 35 in winter, to allow for the longer time required for delivery and collection of letters in the latter season. Later they suggested five days' stay, so that a more frequent service would result.

Jeffreys thereupon forwarded a modified scheme, which compares curiously with present-day procedure. He first undertook to pay the subsistence of four companies of soldiers at New York and Albany. His letter proceeded, "I have built a vessel, the Eagle, of 180 tons and 14 guns, now at Cowes, and I propose as an experiment to make two voyages there and back, each to take five or six months." He asked that the vessel should be considered as a packet boat and the crew protected from impressment. The Council of Trade considered the proposal and rejected it, as they considered no public benefit would arise therefrom.

In spite of this, the Eagle galley proceeded on her voyage, arrived at New York in June, 1703, and was arrested for infringement of the shipping laws. Her crew of 40 included 18 foreigners, the law only allowing 10. In addition, the greater portion of her cargo was Madeira wine, not an English commodity, as the shipping laws required. Inquiry showed she had sailed from Cowes with an English cargo, met, attacked and captured a foreign ship laden with wine, had called at Madeira, landed the English goods, and loaded the wine from the captured vessel. The whole circumstances of the seizure and arrest had to be referred to the home authorities, and although the result is not stated, she had to remain in any case at New York for 12 or 18 months. Jeffreys does not appear to have suggested any other scheme for the same useful purpose, and Mr. Dummer's service remained the only Transatlantic mail and passenger line. The distance from England to Barbadoes or Jamaica is 4,000 miles, compared with 3,000 to New York, but, as Sir Jeffrey Jeffreys pointed out in one of his letters, Dummer's service had the advantage of the Trade Winds.

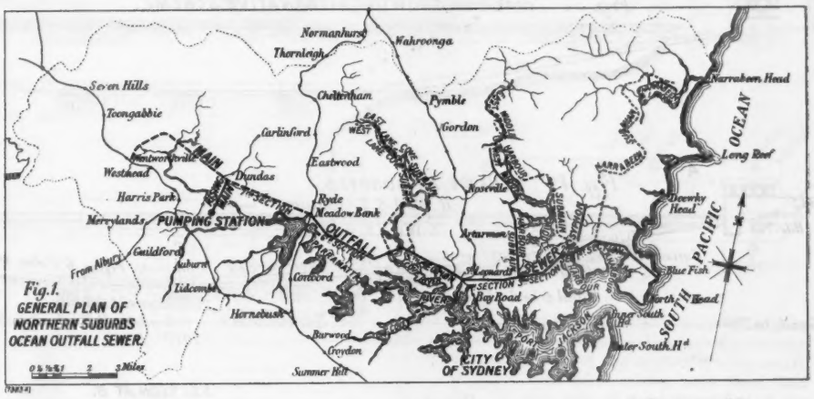
The published official Colonial records do not extend beyond 1708, and the writer is unable to state for how long Mr. Dummer's service continued. Its success during the six years for which the records are available was unqualified and complete, in spite of the difficulties which a state of war must have introduced into its operation, and its great and proved utility should have secured its continuance. But even if, in course of time, it had to be discontinued, Edward Dummer, formerly Surveyor of the Navy, deserves an honoured place in the country's records as a pioneer of the Transatlantic ferry now attained to great and increasing dimensions in incomparably more favourable circumstances. It would have been interesting to know if this pioneer profited by his enterprise. Perhaps it is a slight and favourable sign of his success to find he was returned as member of Parliament for Arundel in 1705.

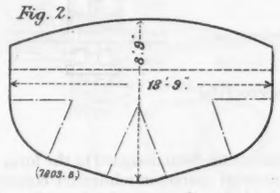
THE OCEAN OUT-FALL SEWER SYPHON UNDER THE MIDDLE HARBOUR, SYDNEY, N.S.W.

THE City of Sydney, N.S.W., Australia, is bounded on the east by the South Pacific Ocean. It is divided into a Northern and a Southern Area by Syndey Harbour and the Parramatta River. The total population of the city and suburbs within the water supply area is 1,060,000, of which 870,000 are in the southern section and 190,000 in the northern section, the city proper being on the southern side of the harbour.

In dealing with the sewering of the city and suburbs the aim has been to abolish all previously-existing treatment works or sewage farms, and discharge the untreated sewage into the ocean. The coast north and south of the entrance to Sydney Harbour on which the city and suburbs abut is characterised by sandstone cliffs forming headlands, and fronted by deep water interspersed at intervals with the well-known sandy surfing beaches of Manly on the north, and Bondi, Coogee and others on the south of the harbour entrance. The coast line as defined by the headlands runs approximately north to south, and an ocean current having a velocity of from 1¼ knots to 1½ knots obtains along it. The prevalent summer wind is from the north-west striking the coast line at an angle of about 30 deg., while the prevalent winter wind is south-west to west, or off the coast. Exhaustive observations show that sewage discharged at any of the more prominent headlands is carried to the southward by the ocean current referred to, and only floating matter offering a considerable surface to the north-east wind is deposited on the beaches, and that on such rare occasions as to be negligible in considering the problem of the ocean disposal of sewage.

In pursuance of the general scheme of ocean disposal of sewage, main outfall sewers to deal with the city proper and the suburbs to the south of Sydney Harbour have now been completed, as also have many of the subsidiary sewers in the same area. These main southern outfalls are three in number: The Bondi main sewer completed in 1887, the Southern Ocean outfall sewer completed in 1916, and a much smaller main sewer dealing with the Vanduse area in 1917. In the case of the two latter the sewer outlets are arranged to discharge from 25 ft. to 30 ft. below ocean low water. An interesting description of the Southern Ocean outfall sewer and of the design of its outlet will be found in the Proceedings of the Institution of Civil Engineers, Vol. cxxii, date 1920-21, Part II.





The engineers have now turned their attention to the suburbs lying on the north side of Sydney Harbour and the Parramatta River, which are at the present time only partially sewered. Where sewerage facilities exist, the sewage is treated in septic tanks or by the activated sludge process, the effluent being ultimately discharged into Sydney Harbour; while the sewage from a small area at Manly is discharged untreated into the ocean. As already stated, the present population on the northern side of the harbour is approximately 190,000, and very great developments are anticipated. By the courtesy of Mr. E. M. de Burgh, M.Inst.C.E., Chief Engineer of the Water Supply and Sewerage Branch of the Public Works Department, N.S.W., we are enabled to give the following account of the work being done in this connection, involving at one point a very interesting reinforced concrete syphon passing under a branch of the harbour. To deal with the sewage of this area, which is shown in the map, Fig. 1, a main sewer has been designed, and is in course of construction, having a length of 20 miles from Blue Fish Point, north of Manly, where the sewer will discharge into the ocean with an outlet similar to that adopted in the case of the Southern Ocean outfall sewer, to Parramatta. This main sewer is, as is the case with the southern district sewers, designed to deal with sewage on the separate system, every effort being made to exclude storm-water, and the discharge is estimated on a future population basis of 1,250,000 persons at 75 gallons per head per day, the maximum flow provided for being fixed at 291 cub. ft. a second, corresponding to a discharge of 42 per cent. of the total daily flow in 6 hours. The sewer, which is mostly in tunnel through sandstone rock, is at the outfall end, 13 ft. 9 in. by 8 ft. 9 in. on a gradient of 1 in 3,100. It is of the section shown in Fig. 2.

The sewage from the areas to be drained by this main sewer will be conveyed thereto by branch sewers in the various valleys and the estimated cost of the work at present rates including two branch intercepting sewers having together a length of about 12 miles on Middle Harbour, is set down at approximately 2,500,000*l.*

The above conveys a general idea of the Sydney Northern Suburbs Ocean outfall sewer, but in this article it is proposed to describe especially a section of the work in connection therewith which is now in progress, namely, the syphon or pressure sewer already referred to under Middle Harbour. Middle Harbour is an arm of Sydney Harbour on the north side, and the Northern Suburbs Ocean outfall sewer is designed to cross it at a point 3½ miles from the outlet of the sewer into the ocean. Middle Harbour joins the main Sydney Harbour half a mile from Sydney Heads, and the rise and fall of the tides follow those of the ocean directly. The range between high and low water spring tides being 6 ft. and between high and low water neaps 3 ft. 9 in. The shores of Middle Harbour consist of cliffs of Hawkesbury sandstone which, with the exception of a few sandy flats, one of which occurs on the eastern side of the harbour in the vicinity of the line of the sewer, run down into deep water. The bottom of Middle Harbour consists of clean sand. The depth of water is such that it is navigable for some

miles, and it is considered desirable that nothing should interfere with a navigable depth of 45 ft. at low water being maintained for a considerable distance above the point where the sewer crosses.

In locating the line of the main sewer most extensive surveys and borings were carried out with the view to finding, if possible, a site where the sandstone rock underlying the harbour occurs at such a depth, say anything up to 100 ft., that a tunnel could be driven through with the assurance that if a fault in the rock were met admitting water into the workings, compressed air could be used without serious risk to the lives of the operatives engaged. These surveys and borings, however, failed to locate rock within a suitable depth at any point on which the line of the main sewer could with advantage be located. Indeed, within the limits in which the main sewer line could be deviated, having regard to the areas to be drained, the borings disclosed the depth of rock from low water spring tides to be not less than 160 ft., while it was impossible from the borings to obtain any assurance that serious fissures in the underlying rock might not be met at or below that depth. It was considered desirable therefore to carry the sewer across the harbour by some other means than tunnelling in the rock.

Rejecting tunnelling through the rock underlying the harbour, and bridging above water being impracticable on account of navigation interests, there remained two alternative methods of constructing the crossing, namely, as a pressure sewer (or as it is frequently designated an inverted syphon) either in the sandy bed of the harbour or on the bed; in either case the level of the sewer being such as would provide a clear depth of not less than 45 ft. at low water spring tides for navigation. The selection of a site on which natural movements of the sand bed, or dredging, would not affect the stability of the work was essential, having due regard to the location of the sewer and length of crossing. Soundings recorded on the harbour charts for a number of years compared with those now taken in connection with the work showed movement in the sand forming a "bar" at the junction of Middle Harbour with the main Sydney Harbour proper, and such movement might be looked for in this position owing to the deposition of sand carried down from the land area draining into Middle Harbour and the action of sea and tide. Above or up-stream of this bar, however, where a depth of water of from 60 ft. to 70 ft. occurs, no movement in the bottom level has been observed, and the indications including the growth of kelp on the bottom, and study of the regimen of the estuary, appear to justify the conclusion that no scour need be feared, while it is probable that the bottom will silt up to the level of any structure placed thereon, and this especially if dredging operations disturb the sand at the bar.

The sand underlying Middle Harbour, denuded from the Hawkesbury sandstone rock, is hard, remarkably clean, and so charged with water that it is impossible to dredge a channel of any depth and reasonable width unless special means be adopted to prevent inflow of sand from the sides. The driving of a tunnel or tubes by means of compressed air through this water-charged sand would be, it is considered, a most difficult and dangerous operation.

While presenting these difficulties to certain operations the sand lends itself admirably to the construction of pile foundations. Experiments (the results of which are fully borne out by the stability of works based thereon) have been made for years past to ascertain the bearing power of timber, concrete, and cast-iron piles both disc and plain, sunk by hydraulic jet in similar sand on the coast and in estuaries in New South Wales, and it is found that concrete piles 12 in. by 12 in. sunk by this means to a depth of 15 ft. sustain a blow of 25 cwt., falling 10 ft. with a yield of less than an inch.

For the foregoing reasons the Middle Harbour sewer crossing has been designed in the form of a pair of 6-ft. internal diameter reinforced concrete pipes to be laid side by side on the bottom of the Harbour at a point where the natural depth, unaltered so far as records extend, is 67 ft. below low water spring tides, and supported on groups of concrete piles, each group of piles carrying a block of reinforced concrete which will form a support or resting place for the pipes and distribute the load over the piles. The piles will be sunk by hydraulic jet with a detachable follower, and the concrete deposited thereon under water by means of chutes, the work being controlled by divers.

The gradient of the sewer being 1 in 2,750, an additional fall of 1·95 is allowed between terminals of the syphon, which has an overall horizontal length of 1,900 ft.; the total fall between sewer inverts at terminal being thus 2·64 ft. The syphon is designed in two pipes each 6 ft. in diameter, so arranged that either one or both pipes can be used; one pipe only will be utilised when the system first comes into operation, or during periods of low flow. The estimated maximum future discharge through the two syphons is 253 cusecs (sub-mains between the syphon and outlet increase the discharge by 38 cusecs to 291 cusecs, the stated ultimate discharge of the main sewer) corresponding to a velocity of 4·48 ft. per second, but provision for increasing this velocity if found necessary for the purpose of removing silt from the syphon pipes is made, as mentioned later.

Two alternative designs were considered. The first, which is illustrated in Fig. 3, provided for a vertical outlet shaft connected to the syphon pipes which were partly on a grade of 1 in 5·75 and partly level, the object being to carry any silt deposited from the sewage forward to the outlet shaft, at the bottom of which a silt chamber with scouring pipes for lifting the silt was provided. It was recognised that while there was no need to anticipate difficulty in sinking the outlet shaft to the required depth of 70 ft. below low water, the work of laying the syphon pipes thereto through the water-charged sand and effecting a junction between them and the shaft presented great difficulties, an opinion which was confirmed by experiments made with a suction dredge in attempting to form a trench in the sand on the line of the syphon towards the outlet shaft location. The second design which is illustrated by Figs. 4 and 5 has accordingly been adopted and will now be more fully described.

The complete syphon, which is in duplicate throughout and provides for separate operation of either pipe line system, consists of inlet chamber and down shaft, the syphon pipes themselves, and outlet chamber. At the inlet chamber provision is made for diverting the sewage by stop boards into one or other of two inlet chambers, each of which connects with a main down shaft designed to act as silt pit for the interception of any heavy silt which may be deposited from the sewage. The inlet chamber and down shaft are covered by suitable housing with provision for lifting gear for removal of silt from the pits, and its discharge into barges for conveyance to sea, and it may be stated that experience with the main outfall sewers already constructed shows that the volume of heavy silt which is deposited under similar conditions is very small.

As already stated the first design prepared for the syphon provided gradients leading forward to the outlet shaft to which any silt tending to deposit in the pipes would be carried, and where provision was made for its removal. In the adopted design the lowest portion of the syphon is near the centre, under the harbour. It is not anticipated that any substantial quantity of silt will pass the silt pits provided at the inlet shaft, which will not be carried through the syhon by the normal velocity of the sewage flow, but should any deposit take place in the syphon, provision is made at the inlet chamber temporarily to back up the sewage in main sewer, when its subsequent release will produce an increased velocity in the syphon considered sufficient to scour it. As a further precaution provision is made at the inlet chamber for the installation, if necessary, of electrically-driven centrifugal pumps further to increase the velocity. It is not, however, thought that it will be found necessary to install such pumps even for occasional use, for in the event of any deposit forming in the pipes not removed by normal velocity of flow, or by the increased velocity due to temporarily banking up, it is believed that a simple scoop dredge can be effectively operated through the pipes on a continuous rope which would satisfactorily remove any such deposit. Further, it is anticipated that when the syphon pipes have been jointed and the joints surrounded with concrete, it will be possible to pump out either line for the purpose of cleansing or other attention.

The main syphon pipes—there are 20 of these in all, or 10 in each row—take off from the down shaft

Fig. 3. DIAGRAM SHOWING ALTERNATIVE SCHEME.

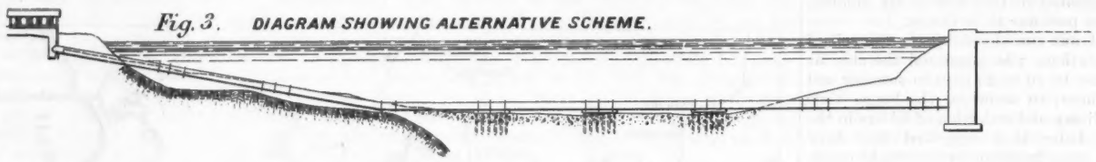


Fig. 4. SCHEME AS ADOPTED.

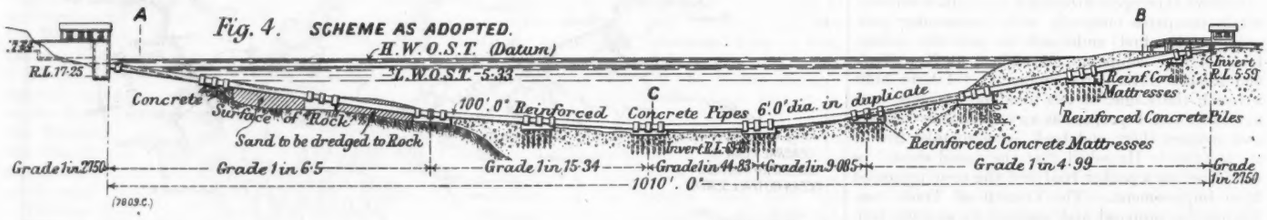
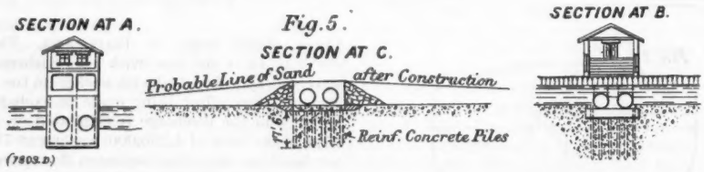


Fig. 5.



on a downward gradient of 1 in 6·5 for a distance (300 ft.), corresponding to three lengths of pipe. They follow then four changes of grade rising to, and terminating in, an outlet chamber connecting with the main sewer. As in the case of the inlet chamber, stop boards are provided here for separate operation of either syphon. The 300 ft. length of syphon adjacent to the inlet chamber will be carried on concrete placed directly on rock foundations, the remainder of the length will rest on concrete bases supported by concrete piling as already described. The syphon pipes are placed 10 ft. 8 in. centre to centre, i.e., with a 3 ft. space between.

The pipes are constructed of reinforced concrete, the details being shown in Figs. 6 to 11, subjoined. A number of the completed pipes are shown in Fig. 15, page 556. The concrete mixture used is one part of cement, 1½ of sand and two parts of ¾-in. gauge basalt; each pipe is of 6-ft. internal diameter by 10 in. thick and 100 ft. long, weighing in air approximately 150 tons. The system of reinforcement is shown in Fig. 6 and the cross-sections Figs. 7 and 8, while it is also well shown in Figs. 17 and 18, page 556. Collars 9 in. in thickness and 6 ft. length are moulded as an enlargement of the pipe at a distance of 12 ft. from each end (see Figs. 6 and 11). This portion of the pipe will rest on the supporting foundations, as shown in Fig. 11. The joints between the pipes are of spigot and socket form shown in Fig. 6, and have been designed so as to allow a maximum of tolerance in respect of the line and level between the pipes with a minimum of leakage. A special groove is provided for the introduction of an elastic packing. The changes of grade which occur in the syphon have been provided for in the moulding of the joints, and special precautions have been taken by means of standard moulding rings to guard against any error in fitting. The moulds for the socket are shown in position in Fig. 18, page 556. After each pair of pipes is laid in position they will be drawn together by means of segmental cast iron collars and 2-in. diameter bolts. Each complete cast-iron collar is built up of six segments, Figs. 9 and 10, and weighs approximately 2¾ tons. After the pipes have been laid on the foundations and the joints drawn tightly together by the bolts referred to, each joint including the cast-iron collars and bolts, will be surrounded with mass concrete in order to insure a watertight joint and also to protect the cast-iron collars and the bolts from the action of the salt water.

The pipes have been designed for the conditions of loading and support shown in Figs. 12 and 13; the stresses given are for loading in air and are, of course, greater than the stresses to which the pipe will be subjected under the ultimate conditions of loading under water. Fig. 12 shows the loading under what are taken as normal conditions, giving a maximum calculated stress in the steel of 10,080 lb. per square inch, and in the concrete of 484 lb. per square inch. Fig. 13 shows the conditions assuming one of the supports to have failed as indicated, the end of one pipe being supported only by the adjacent joint. In these circumstances the maximum stresses are increased to steel 20,418 lb. per square inch, and concrete 645 lb. per square inch.

Deflection tests have also been carried out on the manufactured pipes in the yard after completion. Accurate measurements of deflection were made; the pipe was supported beneath the collars which rested on sand, all support from the intermediate central portion being removed. The observed deflection from a series of tests under these conditions ranged from 0·29 in. to 0·36 in. This may be compared with the calculated deflection, first, on the basis of no tension in the concrete, which gives a deflection of 0·81 in., and secondly, assuming a tension in the concrete of 295 lb. per square inch, which gives a deflection of 0·39 in. It will be seen that the latter assumption corresponds much more nearly with observed results.

Plant has been assembled for the purpose of constructing the foundations and laying the syphon pipes in position, but in the first instance a harbour suction dredge has been utilised for cleaning up any inequalities in the sandy bottom and for removing excess sand at the eastern end of the syphon. For the construction of the foundations a pontoon has been equipped with pile driver, pumps for sinking piles by means of hydraulic jet, concrete mixing plant and divers' equipment. Although the velocity of the tide at the site of the syphon is very small, two galvanised wire steel cables have been laid down, one on each side of the central line of the syphon. These when not in use lie on the bottom of the harbour, but can be tightened by winches so as to come to the surface and act as guides to keep the operating plant over the syphon line.

For the laying of the syphon pipes themselves after the completion of the foundations, other plant has been provided. There is available in Sydney Harbour a naval floating crane which is quite capable of lifting one of the syphon pipes without any buoyancy apparatus attached and placing it in position, and this crane will, if necessary, be used in placing the pipes at the extreme ends of the syphon where the water is too shallow to allow the use of the deep water plant about to be described. It is, however, anticipated that considerable difficulty would be found in keeping the pipes in accurate alignment while handling them with a floating crane and further that the accurate placing of the pipes will be greatly facilitated by the use of buoyancy apparatus.

The plant for placing the pipes consists of the two pontoons shown in Fig. 14, fastened end to end and having an overall length of 132 ft.; each of these pontoons has an available buoyancy, with a reasonable freeboard, of 100 tons, and each is equipped with a powerful steam winch operating tackle passing through a central aperture built in the pontoon. These pontoons are also equipped with concrete mixing gear and air pumps. They are in respect of buoyancy and lifting gear capable of lifting a syphon pipe submerged in the water without the assistance of any buoyancy apparatus attached to the syphon pipe itself. However, in order to reduce the weight to be handled buoyancy tanks will be attached to the pipes. Each set consists of double steel cylinders with the necessary connections for attachment to the upper side of pipes, and fitted with the necessary pipes and valves to provide for the pumping out of the water, or flooding as required. In addition to these cylinders, bulkheads are provided which can be drawn against each end of a syphon pipe by means of one of the

Fig. 6. SECTION THRO' JOINT OF PIPES.

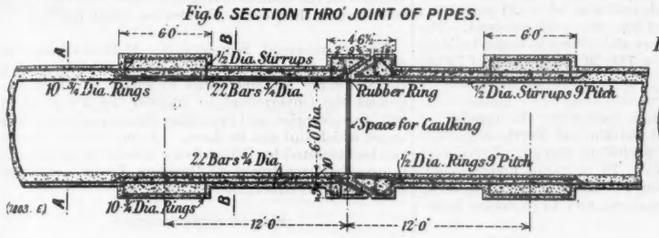


Fig. 7. SEC. A-A.

Fig. 8. SEC. B-B.

DETAIL OF JOINT WITH C.I. FLANGE.

Fig. 9.

Fig. 10.

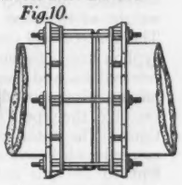


Fig. 11. PLAN OF PIPES, CONNECTING DOWN LEG & UP LEG SHAFTS.

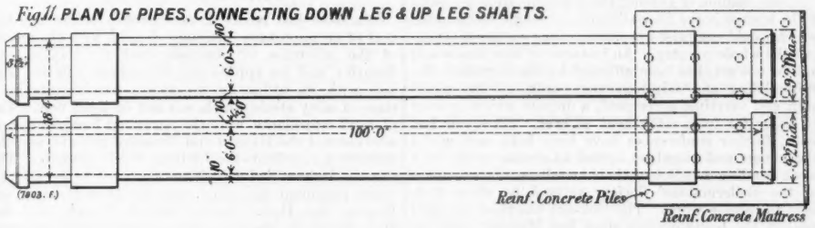


Fig. 12.

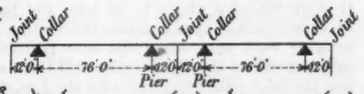


Fig. 13.

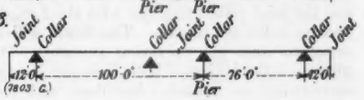


Fig. 14.

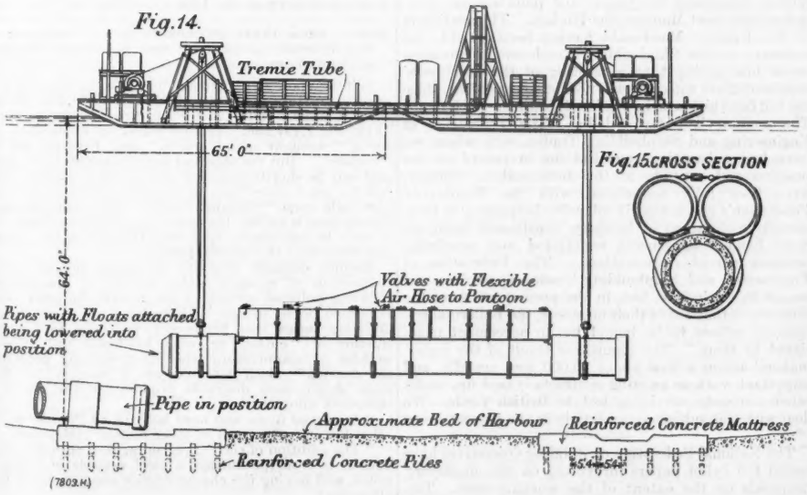


Fig. 15. CROSS SECTION

permanent cast-iron joining collars and bolts. By the use of these bulkheads and pumps any syphon pipe can be emptied and the buoyancy increased accordingly. It is not expected that these bulkheads will be used except possibly in the case of the pipes at the extreme ends of the syphon where the water is too shallow to admit of the steel floats being brought into operation. The work of lifting the pipe with the plant described above will be carried out as follows :—

The pipes have been built on a sandy flat which slopes gradually into the harbour (as shown in the photographs, Figs. 16 and 18, page 556), and they can be readily launched sideways, by rolling, into water of any depth required. After launching a pipe, the steel buoyancy cylinders will be lowered on it from the floating pontoons and connected to the pipe by divers. Water will then be pumped out of the steel buoyancy cylinders and the remaining weight of the pipe taken by the pontoon tackles. The pontoon will then be floated into place over the syphon line between the steel guiding ropes already referred to, and the pontoon with suspended pipe having been moved into position as accurately as possible, the pipe will be lowered on to the foundations. The total weight of each pipe when submerged with buoyancy floats in operation is equivalent to 10 tons only. In order to facilitate the process of drawing the pipes together a steel rope will be used with suitable tackle reeved through the shore end pipes as they are laid. This will be passed through the pipe about to be laid, and hauled in by shore winches, thus assisting the floating plant in drawing each successive pipe into position. The cast-iron collars already described will then be placed and the joint pulled together with the 2 in. diameter joining bolts by divers. The floats will next be detached and the operation repeated. On completion of the laying of both lines the joints will be surrounded as already described with concrete, when it is anticipated they will be sufficiently tight to admit of the syphon being pumped out and the joints finished inside. On completion, and after testing, rock from the adjoining tunnels will be tipped on each side of syphon and the whole left to silt over.

Two points may be mentioned in this connection. First, that the shipping traffic at present using Middle Harbour is extremely small, and there will be no difficulty in arranging for carrying on the work without interruption from shipping at suitable hours; and, secondly, the extreme clearness and brilliancy of the water together with its mild temperature greatly facilitates the work of divers.

With regard to the progress of the work to date, the whole of the pipes have been manufactured and have had ample time to mature. The plant equipment is complete, the grading of the bed of the harbour is finished and the concrete foundations for the syphon pipes where they rest upon the rock on the inlet side have been placed in position while the concrete piles for the foundations in sand have been manufactured and the work of sinking them is now in progress.

The extensive tunnelling operations on each side of Middle Harbour, which must be completed before the sewer can come into use, are not in such a stage as to call for the immediate completion of the syphon, and for that reason the actual work of completing the pile foundations and placing the pipes in position has been advisedly postponed until the coming Australian winter, at which period of the year the prevalence of off-shore winds guarantees smoother working conditions than ordinarily obtain so near the mouth of Sydney Harbour in summer time.

The whole of the work is being carried out by the Public Works Department, N.S.W., without the intervention of a contractor. Mr. E. M. de Burgh, Chief Engineer of the Water Supply and Sewerage Branch of the Department, has been responsible for the design and construction, Mr. Algernon Peake, M.Inst.C.E., being deputy chief engineer. The detailed design of the reinforcement of the pipes to comply with the specified requirements of the chief engineer, together with the actual manufacture of the pipes themselves, was carried out by the State Monier Pipe Works, an industrial undertaking allied to the Public Works Department, which carries out a great deal of reinforced concrete work throughout the State.

INDUSTRIAL NOTES.

AN article in the *Ministry of Labour Gazette* for April contains a number of wages rates on August 4, 1914, compared with those ruling on March 31 last. From this we take the following figures :—Bricklayers, 9·9*d.* against 19·6*d.* per hour, an increase of 98 per cent.; labourers, 6·6*d.* against 14·7*d.*, an increase of 123 per cent. The weekly rates are :—Bricklayers, 40*s.* 7*d.*, and 71*s.* 2*d.*, an increase of 76 per cent.; labourers. 27*s.* and 53*s.* 4*d.*, an increase of 98 per cent. The following weekly figures for the two dates and the percentage increase are also given :—Fitters and turners 38*s.* 11*d.* and 56*s.* 6*d.* = 45 per cent.; ironmoulders, 41*s.* 8*d.* and 59*s.* 2*d.* = 42 per cent.; patternmakers, 42*s.* 1*d.* and 60*s.* 9*d.* = 45 per cent.; labourers, 22*s.* 10*d.* and 40*s.* 3*d.* = 77 per cent.; shipwrights, 41*s.* 4*d.* and 48*s.* 11*d.* = 18 per cent.; shipjoiners, 40*s.* and 50*s.* 9*d.* = 27 per cent.; platers, 40*s.* 4*d.* and 47*s.* 10*d.* = 19 per cent.; riveters, 37*s.* 9*d.* and 45*s.* 3*d.* = 20 per cent.; labourers, 22*s.* 10*d.* and 38*s.* 6*d.* = 69 per cent. The weekly wage of carpenters and joiners in house building was 39*s.* 11*d.*, and is now 71*s.* 2*d.*, an increase of 79 per cent.

According to the same authority, the number of fatal accidents in Great Britain and Northern Ireland during March, was 196, excluding seamen. There were 21 in the railway service, 79 in mines underground, 17 in mines at the surface, 4 in quarries over 20 ft. deep, 60 in factories and workshops, and 15 in docks, buildings and warehouses.

In the opinion of Labour, the consummation devoutly to be wished is the formation of one single trade union which would comprise absolutely every worker throughout the whole country. An instance of how this would act, or not act, has been afforded by the dispute in the shipbuilding and ship-repairing yards, on the night-shift and overtime agreement, a dispute which appears to be as far from settlement as ever. Since our last issue, further conferences have been held, and whilst the joiners and plumbers agreed to resume work for a week pending a ballot of their members, the executive of the Boilermakers' Society refused to allow their men to resume work. The lock-out has thus operated against the boiler-makers since last Monday, and the notices concerning the joiners and plumbers are postponed until next Monday, the 7th inst. The mediation of Mr. Ramsay Macdonald having been sought, the secretary of the Shipbuilding Employers' Federation wrote him saying that a meeting of the employers' representatives with him was not found expedient, since the full facts had been laid before the Minister of Labour. The secretary's letter added: "The Federation of Engineering and Shipbuilding Trades, with whom we have had exhaustive consultations in regard to the position and attitude of the Boilermakers' Society, have been fully acquainted with the Employers' Federation's views, that if collective bargaining is to be usefully maintained in industry, constituent members must honour agreements negotiated and concluded between parent organisations. The Federation of Engineering and Shipbuilding Trades appreciate and accept this principle, but, in the present instance, the difficulty is that one of their members, the Boilermakers' Society, refuses to be bound by an agreement negotiated by them." The immediate result of the boilermakers' action is that about 30,000 men are idle, and important work on existing contracts is held up, whilst other contracts are being lost to British yards. We deal with this subject in an article in the present issue.

The National Federation of Building Operatives have issued the ballot papers for voting on the employers' proposals on the extent of the working-week. Two questions are asked :—(1) Are you in favour of establishing in the National Working Rule Agreement a variation of the present working week, and set up what is known as the "spread over" 44-hour week by a longer working week in the eight summer months, 44 hours for two months and 41½ hours for two months? (2) Are you in favour of maintaining the present maximum 44-hour week for ten months and 41½ hours for two months? The result of the ballot will be known in about a fortnight.

The seventeenth annual report for 1922, recently issued by the Skilled Employment and Apprenticeship Association, states that during the year 252 boys and 502 girls were successfully placed in a number of trades, or 68 boys and 170 girls more than during the preceding year. The offices of the Association are at 75, Denison House, 296, Vauxhall Bridge-road, S.W.1.

Negotiations between operatives in the railway wagon building and repairing trades and the Employers' Associations on the question of new wages proposals have come to a satisfactory issue. Following a ballot, a memorandum has been agreed upon stating :—

"That the rates of the workpeople remain as at present, plus the 10*s.* balance of the 26*s.* 6*d.* war bonus, until March 31, 1924, unless in the meantime the balance of 10*s.* is altered in the engineering trade, in which case any variation, up or down, made in the engineering trade may be discussed by the parties to this memorandum.

"The remaining 5 per cent. of the Churchill award to be discontinued on the understanding that on all wages earned on and after April 30, 1923, a flat rate increase of 2*s.* 6*d.* per week will be made on time-workers rates, this increase to be regarded as taking the place of the 5 per cent. Churchill award, and to apply only to time-workers who were entitled to be paid the Churchill award.

"The terms embodied in this memorandum will only apply conditionally on the present 10 per cent. addition to the 'pink-backed' price list being reduced to 5 per cent. for all workers working to the 'pink-backed' price-list, and on the understanding that there is an equivalent reduction on the piece-work rates for wagon builders."

The Commercial Secretary to H.M. Embassy at Rome has forwarded a copy and translation of a Royal Decree No. 399, dated February 8, which empowers the Government to transfer the telephone to private enterprise, and prescribes the general conditions under which this can be done. A copy of the Decree can be inspected by British firms interested on application to the Department of Overseas Trade (Room 52), 35, Old Queen-street, London, S.W. 1.

STAINLESS STEEL.

WE have just received, and publish below, the full text of an important judgment dealing with the merits of the invention of stainless steel by Haynes and Brearley and its application to various utilities, and also with its utilisation to obtain new results by a class of alloy steels which was not in itself new. The plaintiff appellants were the American Steel Company, who control the Haynes and Brearley patents, and the defendant appellants the Ludlum Steel Company. The Circuit Judges, before whom the case came and by whom judgment was given, were the Hon. Henry Wade Rogers, the Hon. Charles Merrell Hough, and the Hon. Martin T. Manton. The full text of the judgment which was given on the 19th ult., follows :—

APPEAL FROM FINAL DECREE IN EQUITY ENTERED IN THE DISTRICT COURT FOR THE SOUTHERN DISTRICT OF NEW YORK.

Suit is upon two patents, one (Claims 1, 2 and 4) granted to Haynes, April 1, 1919, No. 1,299,404, and the other (Claims 1 and 3) granted to Brearley, September 5, 1916, No. 1,197,256. Haynes called his application one for a "wrought metal article," and Brearley his for "cutlery." But the object of both patentees is the same, and may be shortly described as a desire to produce what has for some years been increasingly well known under the trade name "Stainless Steel." Although Brearley's patent date is earlier, his date of application is later, and it may be summarily held that Haynes' is the generic and Brearley's the specific patent.

Haynes declares that his invention relates to the production of wrought metal articles of manufacture "having polished surfaces of the general character which is termed noble, in that such surfaces are incorrodible." Brearley states that his invention relates to the production of "cutlery or other hardened and polished articles of manufacture where non-staining properties are desired." Both patentees are of opinion that they have shown such desirable product by the use of a described alloy, to wit :—

"A worked down and hard body of an iron-chromium alloy low in carbon and in other metals" (Haynes).

"The addition of certain percentages of chromium and carbon to iron (producing) a steel capable of taking a polish and having the characteristics above referred to" (Brearley).

Haynes' most specific claim is No. 2, viz. : "A wrought metal tool having polished surfaces of the incorrodible character of polished surfaces of noble metal and comprising an alloy of iron and chromium containing from 8 per cent. to 60 per cent. of chromium and from 40 per cent. to 92 per cent. of iron, with carbon in amount between 0·1 per cent. and 1 per cent., said alloy being readily malleable and workable, and being substantially free of other metals."

Brearley's definition of his own invention is best found in his first claim, viz. : "A hardened and polished article of manufacture composed of a ferrous alloy containing between nine per cent. (9 %) and sixteen per cent. (16 %) of chromium and carbon in quantity less than seven-tenths per cent. (0·7 %)."

Defendant is alleged to infringe by making and selling certain kinds of steel known by the trade names of "Nevastain" and "Silchrome." The ultimate manufactured article, tool or implement does not appear to have been made by defendant, but what it sells is by its own commercial literature described thus : "Nevastain is a high chromium, silicon alloy completely resistant to the effects of fruit acids . . . It is particularly adapted for exposed surfaces which have to withstand the combined action of salt water and the atmosphere. It can be hardened by the usual methods and made file hard, and can then be drawn to requirements. . . .

Nevastain steel, when polished, will retain its high finish indefinitely. The atmospheric dirt can be readily removed by soap and water."

"Silchrome is very resistant to the action of acids, organic and inorganic. It will not stain when subjected to the fruit acids, providing the steel has been hardened."

The usual defences were interposed, and the court below in a careful and able opinion by Learned Hand, J., set out substantially all the facts adduced at hearing, and held that the Brearley claims in suit could not "create a monopoly over the whole extent which they claimed," but that said claims might be considered (for argument's sake) "valid for as much of the field as (Brearley's) invention really covers."

No definite finding of validity was made in respect of Haynes, but non-infringement of both patents was declared (as to Brearley) because if his disclosure were followed, defendant's alloy or composition "would become hard and would not become stainless," and as to Haynes, his disclosure nowhere indicated any method of rendering stainless what defendant had made and sold. From decree dismission bill for non-infringement plaintiff appealed.

Charles Neave for appellant.

Alan D. Kenyon for appellee.

HOUGH, C. J.

Judgment, in this case, seems to us primarily to depend on ascertainment of patent validity and scope. This is a prerequisite to determination of the place in the art, or that branch of art, to which the patents belong. If this invention be found broadly new, meritorious in ingenuity, and lying at the foundation of a wholly novel development of human labour—it should receive in construction a liberality too well recognised to need additional exposition; though we may point out that Treibacher *v.* Roessler, 219 Fed. 210, is a rather striking illustration of such appropriate liberality.

The history of steel is almost as old as that of commerce, and the story of its use for tools of every kind a commonplace, but equally has it heretofore been a commonplace that unless kept bright by repeated polishing or protected with oil, the steel utensil was expected to lose its lustre—and especially have all steel articles needed protection from the common acids of human food; something usually at hand, and certainly as much needed as steel itself.

The difficulty of producing a steel resistant to what is roughly called "corrosion" even by some of the experts testifying herein—has long been recognised. That compound of pure iron and the carbide thereof which is steel, has itself been admixed (for many purposes) with other and more infrequent metals; *e.g.*, nickel, tungsten, &c., and chromium. Ferro-chromium is one form of admixture; and the fact that ferro-chromium itself was well known to be peculiarly resistant to powerful acids doubtless suggested years ago that some chromium alloy might be at once useful for many of the commercial purposes of steel and yet maintain its polished lustre. This record is replete with accounts of speculation on this subject and dissertations thereon by men confessedly skilful in their day in the arts of steel-making and metallurgy. These publications have been advanced by defendant to minimise the inventive concept of Haynes and Brearley. To us they magnify it.

There are many inventions which seem to have been gathered, as it were, from the scrap heaps of human effort—they appear to observers as the results of accident, rather than intelligent design. But where men doubtless well equipped for a particular sort of work have hoped and investigated and even prophesied as to what could be done, but never did it, and other men similarly equipped have by intensive study and skilful experiment succeeded, such success commands and should receive a greater meed of intellectual appreciation than is accorded even to the cleverness of picking up and utilising an unconsidered or discarded trifle. When to the scientific triumph of succeeding where other scientists have failed, is added development of a new branch of industry, the word "pioneer" may well be accorded to the patent which describes and defines, even though lamely, the essentials of such success.

Half a century ago Woods and Clark (British No. 1,923 of 1872) filed provisional specification for an "improved alloy for anti-acid metal"; but they never completed their application. Of this abandoned disclosure defendant declares that these men taught the world . . . that high chromium ferrous alloys consisting of low carbon Bessemer steel and high chromium content with more or less tungsten," could be used to produce stainless alloys; and it is urged that "the patents in suit have added nothing to that knowledge." On the contrary, our inference is that Woods and Clark must have thought little of their own concept, as they dropped the matter at once; while examination of their disclosure shows that their preferred alloy for "anti-acid metal" was made in proportions wholly wrong, while their methods of production were merely impossible. They were perhaps among the prophets; but it requires more than prophesy of what may be done, or than declarations of what ought to be accomplished, to make a good patent reference, not to speak of an anticipation. It is necessary to show with reasonable certainty how the desired result can be accomplished. (Westinghouse, &c., Company *v.* Great Northern Company, 88 Fed. 258.)

In 1892 Sir Robert Hadfield investigated chromium steel and published his results. That publication we regard as potent evidence of what were then regarded as insuperable difficulties in attaining permanent lustre in steel. We accept that eminent steel-maker's statement, made in 1916, that he in 1892 saw no way of utilising low-carbon high-chromium steel for making articles capable of remaining untarnished in contact with the common acids.

We have taken from the historical evidence one example of thought expressed in a patent specification, and one of thought expressed in scientific dissertation; the quotations might be much extended, for all the evidence unites to prove that steel of a polished lustre secured by its composition against the commoner forms of acid or corrosive attack, was something sought for, suspected as possible to come from chromium admixtures—but never obtained until contemporaneously in England and the United States, Brearley and Haynes, proceeding along similar lines and having in view substantially the same purpose, produced as a new article of manufacture, a wholly novel product, and something almost in denial of previous scientific disclosures—"Stainless Steel." To such an inventive concept the often misleading word "pioneer" may fairly be applied.

Having thus given our view of the rank of this inventive thought, the question is crucial (in considering validity). To whom were these patents addressed? Who were the "men skilled in the art" to whom they spoke—and by whose intelligent appreciation they are to be measured as to clarity and sufficiency of disclosure? Here we are constrained to disagree with the learned District Court; where these patents were measured by what a cutler would learn from them, and more particularly from Brearley. A cutler may mean either a man who makes edged tools, or one who grinds them. He has nothing to do with the manufacture of the steel, which for him is raw material. Yet these patents refer to the production or making of a certain kind of steel; they instruct with remarkable precision as to the component parts of the material, which is to be stainless. It seems to us clear that such a disclosure speaks directly to those whose business it is to make the steel, and not to the cutler who is to fashion it.

We have recently considered the meaning of the phrase "man skilled in the art"; and concluded that it is always a relative term; and that no absolute definition of its meaning can be laid down as matter of law; because the query as to who is the man skilled in any particular art is itself a question of fact and one having regard to the patent under consideration (Dick *v.* Barnett, C. C. A., 2nd, Mar. 5, 1923).

It follows that we are of opinion that these patents are to be interpreted in the light of what their disclosures would mean to one accustomed to the art of making steel, or to a metallurgist, and not to one who was concerned only with the forming thereof into implements of industry.

What the patentees told metallurgists was that stainlessness might, and would, be attained by the making of low carbon and (comparatively) high chromium alloys when, and only when, what Haynes called "special precautions" were taken in preparation; substantially that crucibles differing from those in ordinary use should be availed of in order to prevent the proximity and consequent admixture of carbonaceous matter during the process of melting. Haynes thought that he could use either electric or fire heat, while Brearley preferentially recommended an electric arc-melting furnace. The product of both depended upon the making (under melting conditions as above set forth) of an alloy of iron in which the admixture of chromium was in Haynes to be from 8 per cent. to 60 per cent. with a content of between 10 per cent. and 25 per cent. preferred; and in Brearley (who devoted himself to a material particularly suitable for tools) between 9 per cent. and 16 per cent.; while Haynes carbon might run from 0·1 per cent. to 1 per cent. and Brearley's must be less than 0·7 per cent. The patented product is according to Haynes to be (*inter alia*) a "hard body of an iron chromium alloy"; and according to Brearley, "a tempered steel hardened article." The non-infringement hitherto declared is based on consideration of the words hard or hardened.

Defendant's "Nevastain" and "Silchrome" show an average (in figures near enough for discussion) of carbon 0·43, chromium 9·73, and an addition of silicon 3·84. Leaving silicon out of consideration for the moment, and accepting defendant's laudatory comments on its own product (prefixed to this opinion), it is evident that the alleged infringing articles have taken not only the proportions of both patents, but (as will appear on closer reading of his disclosure) the especially preferred compound or admixture of Brearley.

It was found below and (as may be assumed for purposes of discussion) that such steels as "Nevastain" and "Silchrome" will often (it is believed always) become hard if heated to the critical temperature taken with the utmost liberality, but will not be stainless. They must be heated further, and to 1,700 deg. F. to acquire that second character" of stainlessness. The degree of heat indicated is distinctly above the critical temperature of ordinary steel. This means, without going into a detail which may be pursued in the opinion below, that since the patents were addressed to the cutler, and the cutler was accustomed to harden steel, which is his raw material, by heating to and slightly beyond what is known as the "critical temperature," he ought to have been told by the disclosure not only that he must harden steel (which was an old story) but to just what degree of heat he must proceed in order to attain not only hardness but stainlessness.

It is admitted that both the patents plainly disclose a hard steel, particularly when the chromium is low; and it is also admitted that the process of hardening generally is not a matter of heating to a fixed point. While it has long been known that the critical point of any steel may be indicated by pyrometric instruments, well known in commerce, it is also proven that even among artisans, including cutlers, the practice of skilled men has been to determine the proper hardening or heating point empirically. We do not go into the exact number of heat degrees above the critical point of ordinary steel to which steels like defendant's or Brearley's preferred product (minus the silicon) must be heated to ensure stainlessness, because we do not think the exact number of degrees makes any difference, and are of opinion that such higher degree of heat is very far within the professional knowledge of the metallurgist or steel-maker, by whose competency these patents are to be judged. Indeed, we are of the opinion that the determination of such proper degree of heat is within even the range of a workman's competency under what has been called the "try it and see" rule of Bethlehem, &c., Company *v.* Niles, &c., Company, 166 Fed., 880, affirmed 173 Fed. 1,019; Pittsburgh, &c., Company *v.* Seaman Company, 248 Fed., 705).

It is worthy of note that this slight extra or additional heating, in order to ensure stainlessness, does not affect the whole range of proportions as prescribed by either or both patentees. It seems to be true of a comparatively small number of the possible and contemplated variations in carbon and chromium content. The reasons for it are not apparent—to us at all events. Defendant in effect insists, that since the invention relates to stainlessness, and the instructions on that subject are good for all but a small area of the ground covered by the claims, he is free of infringement if he stays in that area. The argument does not prevail, because we think the instructions good enough for the class by whose attainments the disclosure is to be tested.

The facts of this particular case seem to us a perfect illustration of the unfairness of reading these patents by the light of a cutler's (rather under-estimated) workaday knowledge. If the patents were to be judged by what a cutler could make out of them, and it were true that the best cutler did not know enough to properly harden the stainless steel of the patents after reading the disclosures, such ignorant workman could never infringe. But the defendant is not a cutler, but an incorporated steel-maker, equipped with the professional skill of metallurgists; and it is plain enough that the patents were full of instruction for men of the grade of the infringer; and it is to us a strange argument that substantially alleges non-infringement of a patent by a metallurgist because a cutler would not understand what the patentee was trying to express, when the metallurgist had no difficulty in the premises.

It was held below, and has not been here successfully disputed, that omitting silicon defendant has produced stainless steel; with the silicon added it has also produced stainless steel; therefore in respect of infringement the silicon is immaterial, no matter how beneficial it may be. It was not thought necessary below, and we do not think it necessary to dwell upon the differences between the Haynes and Brearley patents. It is enough for the purposes of this case that defendant's product is within the disclosure of both. Whether there may not be in Haynes an attempt to cover too much ground is a question that may be left until occasion for decision arises.

Decree reversed with costs and case remanded to the District Court for further proceedings in accordance with this opinion.

THE ENGLISH ELECTRIC JOURNAL.—The April issue of this publication of the English Electric Company is mainly devoted to a series of excellent illustrations of machinery and apparatus constructed or put into operation by the company in the year 1922. The illustrations cover electric locomotives, tram cars, motor-bus bodies, steam and water turbines, Diesel engines, generators, converters, transformers, &c., and are remarkable evidence of the wide activities of the company.

GREENWICH HOSPITAL NAVAL SCHOOL.—We understand that the Lords Commissioners of the Admiralty have decided to remove the Royal Hospital School, Greenwich, to a new site at Holbrook, in Suffolk. The site, which was recently presented to Greenwich Hospital by Mr. G. S. Reade, borders on the Stour Estuary, and is situated only a few miles from the naval training establishment at Shotley, to which establishment the boys from Greenwich are discharged on entry into the Navy.

THE INSTITUTION OF GAS ENGINEERS.—The Transactions of this Institution, for 1921–22, recently issued, form a volume of 490 pages, which gives the proceedings of the meetings of June last, the address of the president, Mr. Thomas Hardie, the seventh report of the Gas Investigation Committee, the report of the Life of Gas Meters Joint Committee, and several papers with the discussion thereon. The proceedings which it records are those of the fifty-ninth annual general meeting of the Institution. It can be obtained from the offices of the latter, 28, Grosvenor Gardens, Westminster, S.W. 1, or from Messrs. E. and F. N. Spon, Limited, 57, Haymarket, S.W. 1.

THE INSTITUTION OF CIVIL ENGINEERS.—The Council of the Institution of Civil Engineers have made the following awards in respect of papers read and discussed at the ordinary meetings during the session 1922–23: Telford medals to Mr. H. W. H. Richards (London) and Mr. E. O. Forster Brown (London); a George Stephenson medal to Mr. Asa Binns, M.Inst.C.E. (London); a Watt medal to Mr. A. B. Buckley, Junior, O.B.E., Assoc.M.Inst.C.E. (Winchester); Telford premiums to Mr. W. A. Fraser, M.Inst.C.E. (Edinburgh); Mr. S. L. Rothery, Assoc.M.Inst.C.E. (Calexico, U.S.A.); Mr. Mark Randall (Johannesburg); and Mr. D. E. Lloyd-Davies, M.Inst.C.E. (Cape Town); an Indian premium to Mr. D. H. Remfrey, Assoc.M.Inst.C.E. (Calcutta); a Manby premium to Mr. F. M. G. Du-Plat-Taylor, M.Inst.C.E. (London); and a Crampton prize to Mr. F. W. Jameson (Kimberley).

20-CWT. ELECTRIC RUNABOUT CRANE.

FOR the loading and unloading of goods, and for the handling of miscellaneous material in factories or warehouses there is probably no more convenient machine than a self-propelled electric jib-crane. It can travel about, either loaded or unloaded, under its own power and as it produces neither heat, steam nor smoke it can be used in situations where no engine-drive cranes could be permitted. The illustrations on this page show a new type of electric runabout crane, of which three have been recently supplied by Messrs. Veritys, Limited, of Aston, Birmingham, to the order of the Port of London Authority. The crane in question has been designed primarily for use about dock sheds, wharves, railway sidings, goods sheds, &c., and has a greater adaptability than is commonly found in such machines. It is suitable for loads up to 20 cwt., and will handle them from a depth of 15 ft. below floor-level to a height of 12 ft. above. The working radius at full load is 10 ft., and 14 ft. at half-load. The hoisting speed is 40 ft. per minute and the crane will travel either backwards or forwards at 300 ft. per minute and will slew at 3 r.p.m.

The crane is fitted with three Verity motors, one for travelling, one for hoisting and one for slewing and derricking. The drives for the latter motions are by means of friction clutches, so connected that when the clutch is engaged for one motion, the other clutch is automatically withdrawn to its neutral position. An automatic brake is fitted to the derricking motion shaft and interlocked with the clutch lever, so that the jib is held fast when the slewing motion is wanted. Magnetically-controlled brakes are fitted to both the travelling and hoisting motions, so that should current to the motors be interrupted, either accidentally or otherwise, the brakes automatically come into action. The usual clumsy footbrake is thus done away with, and greater security obtained.

The hoisting drum is driven by an enclosed worm gear, the wheel having phosphor-bronze teeth cut from the solid, and running in an oil bath. The driving motor is direct-coupled to the wormshaft and the controller is conveniently placed near the driver in the right-hand side of the cab. The travelling motor is underneath the bottom carriage and drives one of the axles through spur reduction gear and worm gear differential, much as in the case of a motor car. The road wheels are of cast-steel with twin solid rubber tyres and roller bearings are fitted. Steering is effected by means of Ackerman axles in one pair of road wheels. The steering hand wheel is prominently shown in Fig. 2. This drives, by means of worm gear, a shaft passing down through the centre of the king-post and connected to the steering axles underneath. When the crane is not required for travelling, a claw-clutch near the steering wheel is disengaged and the crane superstructure is then free for slewing.

The two upper ropes shown in Fig. 2 are for derricking. Their outer ends are connected to a bracket on the jib, and the inner ends are wound round the derricking drum, which is operated by means of worm gear by the motor seen in the foreground. The same motor is used for slewing as already mentioned. The two motions of hoisting and derricking or hoisting and slewing can be carried out simultaneously. The crane superstructure turns on a large ball-race, about 4 ft. diameter, mounted on the under-carriage, a worm gear on the centre post causing the slewing motion. The jib is curved to facilitate the loading and unloading of railway trucks. The batteries for operating the crane are carried in the box at the back, their weight acting as a counterbalance to the load on the jib, although the crane is stable with the batteries removed. These consist of 25 cells of Exide manufacture, with a capacity of 323 ampere hours. The crane can, of course, be operated by flexible cables from any suitable source of electric supply.

The crane has been designed by Mr. C. H. Woodfield, M.I.Mech.E., and constructed by Messrs. Woodfield and Co., of 6, Queen Anne's Gate, London, S.W. 1.

PERIODIC STILL FOR EXPERIMENTAL WORK.

ENGINEERS in general, and chemical engineers in particular, are fully aware of the fact that a very important distinction exists between chemical processes carried out with a few grammes of material contained in glass vessels in the laboratory and similar processes conducted on a commercial scale. It will be obvious, for instance, that to secure uniformity of temperature throughout a mass of material weighing some tons is a far more difficult matter than would be the case if only an ounce or two of the substance were employed. Some operations, in fact, which are comparatively simple in the laboratory, are quite impracticable to carry out on a commercial scale, and in any case mass action materially affects the results

20-CWT. ELECTRIC RUNABOUT CRANE.

CONSTRUCTED BY MESSRS. WOODFIELD AND CO., ENGINEERS, LONDON.

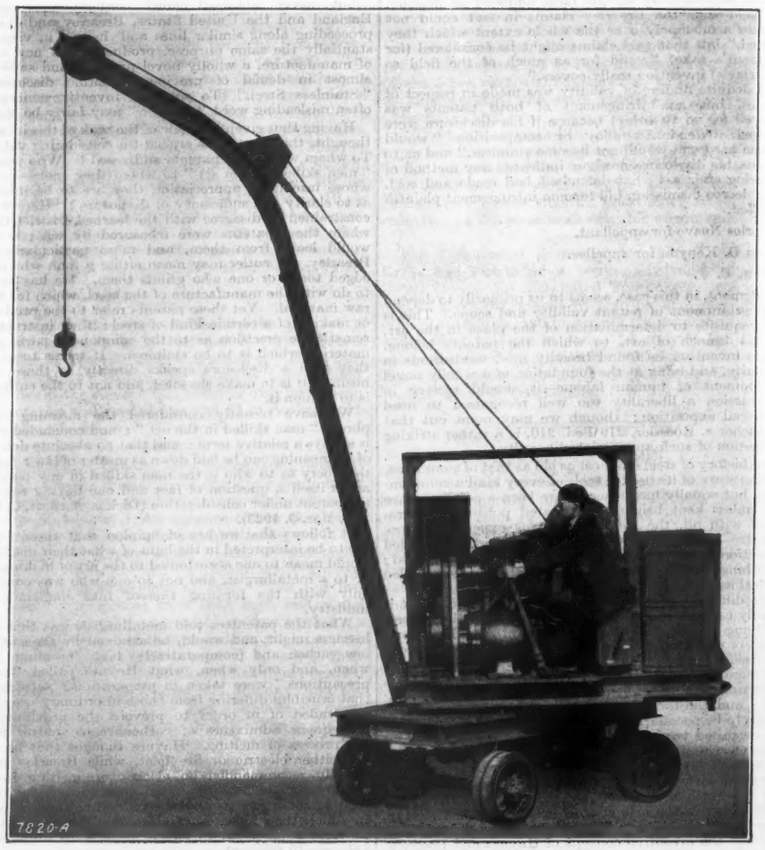


FIG. 1.

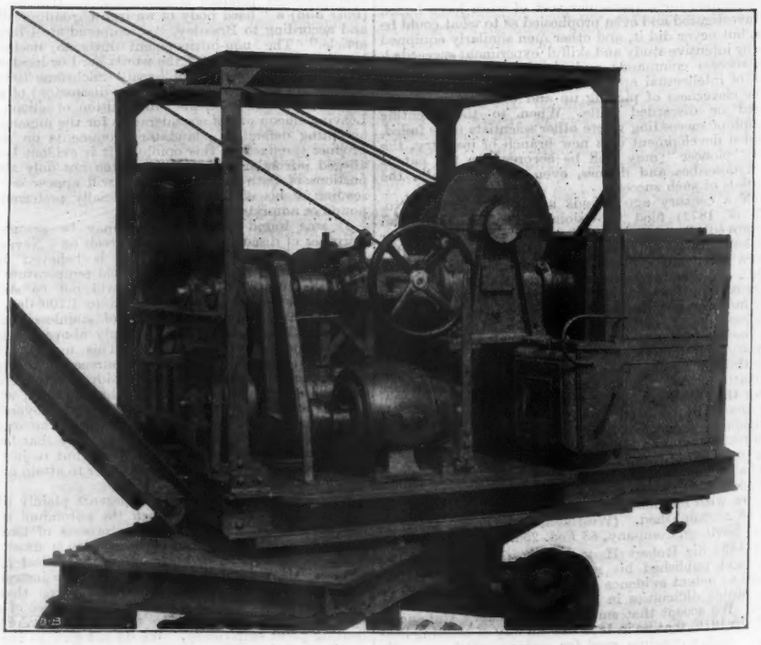
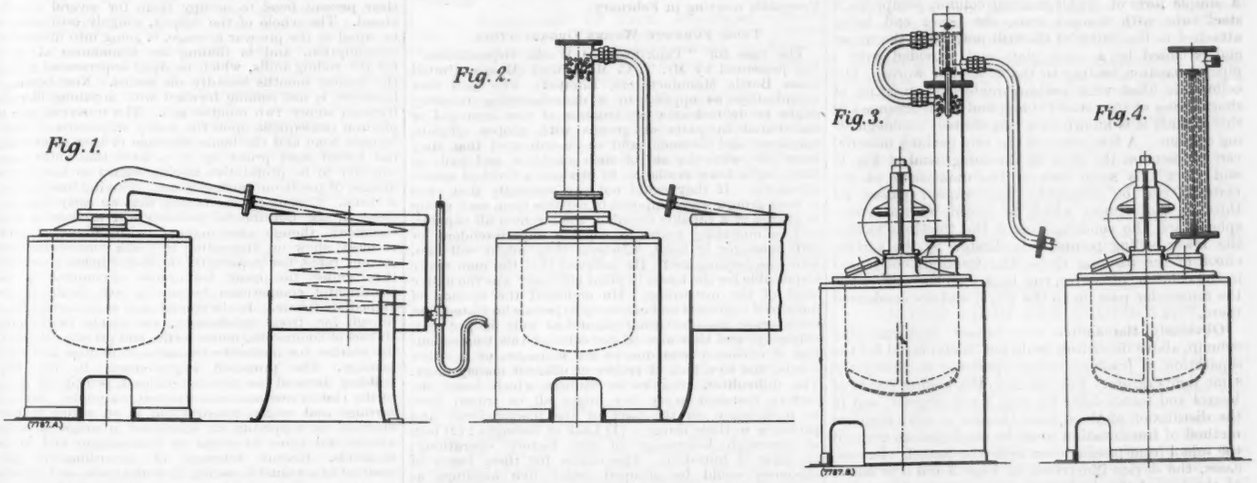


FIG. 2.

PERIODIC STILL FOR EXPERIMENTAL WORK.

CONSTRUCTED BY MESSRS. W. J. FRASER AND CO., LIMITED, ENGINEERS, DAGENHAM, ESSEX.



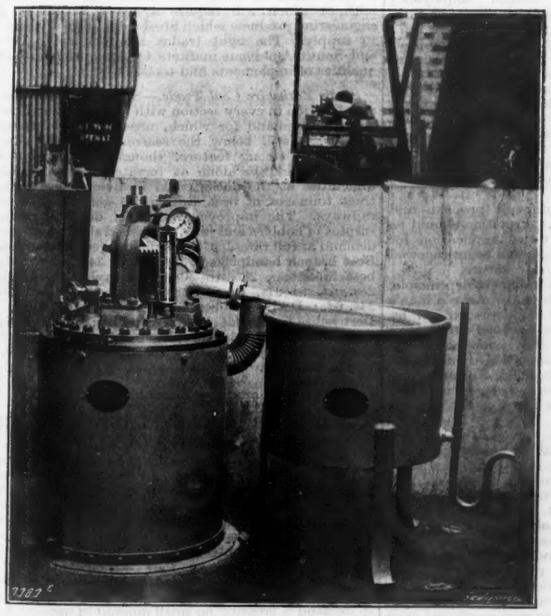


FIG. 5.

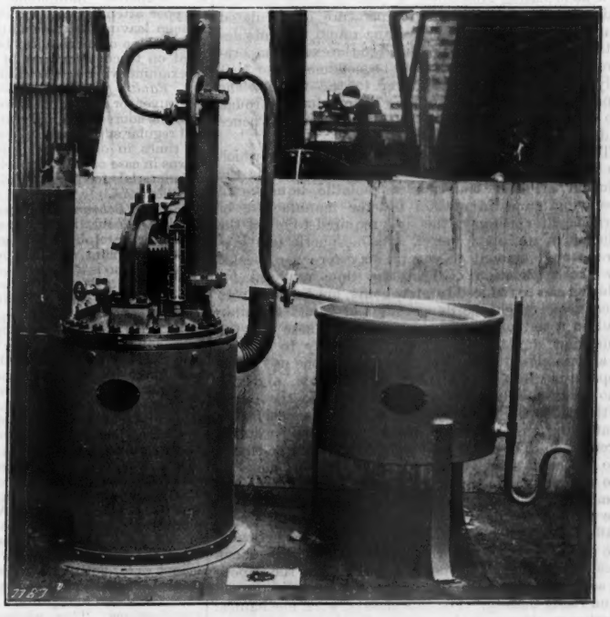


FIG. 6.

obtained in industrial chemical processes. It is desirable, therefore, when a new manufacturing process is being considered or modifications to existing processes are contemplated, to investigate the matter on what may be described as a semi-commercial scale, using a few pounds or gallons of material in order to bridge the gap between the test tube and the manufacturing plant. Apparatus suitable for such investigations, as far as distillation processes are concerned, is shown in the accompanying engravings, Figs. 1 to 6, which illustrate the standard periodic still manufactured by Messrs. W. J. Fraser and Co., Limited, of Dagenham, Essex. This still was recently exhibited by the firm at the London Section of the British Industries Fair, as mentioned on page 232 *ante*. The actual capacity of the still illustrated is 15 gallons, but its special feature is that with a few components it can be arranged for practically any distillation process at present employed. It is thus particularly suitable for use by research chemists who may wish to try the effect of modifications in the process of distilling some substance, although it would doubtless be useful to manufacturers requiring only a comparatively small quantity of any particular product.

The pot of the still is usually of cast-iron, but it can, of course, be made of any special acid-resisting alloy, or it may be enamelled internally if required. A cast-iron cover is bolted on to a flange on the pot, and this cover may be either plain or fitted with a mechanical stirring device, as shown in Figs. 3 to 6. From the remaining figures it will be seen that, when a plain cover is used, the vapour outlet is central and is made as large as possible, but the employment of a mechanical stirrer involves the use of a rather smaller outlet, which is situated off the centre. The pot is designed for working pressures up to 60 lb. per square inch and the cover is provided with the usual fittings, including a thermometer, pressure gauge, safety valve, and an opening for filling. The method of heating naturally depends upon the material to be distilled and the conditions under which the process is to be conducted, but as any one of three different methods can be applied to the same pot, practically all requirements can be met. For the highest temperatures, direct heating by gas flame is necessary, but for temperatures up to about 600 deg. F. the pot may be fitted into an oil bath, the latter being heated by a gas flame. A thermometer is fitted in the oil bath to indicate the temperature and a thermostat is also provided to keep the temperature constant by regulating the gas supply. The makers state that, at moderate temperatures, the risk of carbonisation of the oil is small, and in any case the oil bath can easily be detached for cleaning purposes. When gas heating is employed, either with or without an oil bath, a light steel casing is fitted round the pot with a connection for the escape of the products of combustion as shown in Figs. 5 and 6. The third method of heating is by means of a steam jacket which would be used for temperatures up to about 300 deg. F. in cases where the presence of a naked flame would be dangerous.

In the simplest form of still, the vapour is taken through a trunk head directly to a worm condenser which is immersed in water circulated by thermo-syphon; Fig. 1 is an example of a still so arranged, and in Fig. 5 another is shown having a mechanical stirrer fitted to the pot. The distillate issues through the safety syphon seen on the right of the illustrations, the object of the syphon being to prevent the escape of gases into the building. Any uncondensed gases are allowed to escape through the vertical pipe shown, which is continued upwards through the roof. If the distillation is to be carried out *in vacuo*, the outlet is connected to a pair of receiving tanks which, in turn, communicate with a vacuum pump; the pipe connections and valves are arranged so that one tank is filling with distillate while the other is being emptied.

In Fig. 2 the still is shown fitted with a dephlegmating

column, the object of which is to remove from the vapour any fraction not required to pass into the condenser. The term dephlegmating, we may remark, originated in the removal of a kind of scum, known as "phlegm," produced in the distillation of alcohol. A simple form of dephlegmating column comprises a steel tube with flanged ends, the lower end being attached to the outlet of the still pot, while the upper end is closed by a cover plate and provided with a pipe connection leading to the condenser worm. The column is filled with packing material consisting of short pieces of thin steel tubing, and when arranged in this manner it is known as a ring-contact dephlegmating column. A few pieces of the ring packing material can be seen on the floor in the foreground of Fig. 6, and from this some idea of the dimensions of the material can be obtained. The vapour passes up through the column, which is cooled by the atmosphere, and the condensation of the fractions having the lower boiling points is facilitated by the surface effect of the packing rings. The fractions condensed in the column, of course, run back into the still, while the remainder pass on to the worm and are condensed there.

Obviously the simple ring-contact dephlegmating column, above described, could not be employed for the separation of fractions which condense at nearly the same temperature. For instance, the boiling points of benzol and toluol differ by only a few degrees, and in the distillation of these from tar oils, a more accurate method of fractionation must be employed to prevent the toluol from passing over with the benzol. In such cases, the device illustrated in Figs. 3 and 6 is added at the top of the dephlegmating column. It consists of a steel casing containing a nest of tubes through which water at a definite temperature is circulated continuously. The vapour passing round the outsides of the tubes is in this way reduced to the exact temperature at which the toluol will be condensed, so that only benzol vapour passes over to the worm. The condensed toluol returns to the main column through the syphon trap shown in the illustrations and thence finds its way back into the still.

The only other application of the apparatus to which we now propose to refer is its use for facilitating the solution of solid materials in volatile liquids. In dissolving gums in alcohol for the manufacture of varnishes, for instance, the time required to effect the solution in an open vessel, at atmospheric temperature, would amount to several days or even weeks. By the application of heat the time required for solution can be reduced to a few hours, but heating in an open vessel might be dangerous and would certainly lead to a serious loss of the solvent. These and the somewhat similar objections which apply to heating in a plain closed vessel, are overcome by the use of the apparatus illustrated in Fig. 4. In this, a device known as a reflux condenser, is fitted to the outlet of the still pot. The condenser consists of a steel casing containing a nest of tubes around which cold water is circulated. The usual method of operation is to charge the pot with solid gums and liquid solvent, close up the opening and apply heat. The heat evaporates some of the solvent and the vapour, which rises up into the condenser tubes, is condensed on the water-cooled walls and runs back into the pot. The condenser tubes are closed at their upper ends, so that no vapour can escape, but the arrangement, by condensing the vapour as soon as it is formed, prevents the pressure in the pot from rising unduly. For this class of work mechanical stirring would usually be employed and this still further reduces the time required for solution.

Other arrangements of the apparatus are, of course, possible for special purposes, the applications mentioned above being quoted merely as examples of common practice. They may, however, be taken as an indication of the general utility of the apparatus for the investigation of some of the problems arising in the chemical industries. In conclusion, we would remark that although the still we have described is of comparatively small capacity, Messrs. Fraser specialise in the design and construction of stills and other special plant for chemical manufacturers on an industrial scale.

SOCIETY OF GLASS TECHNOLOGY.

THE sixth annual general meeting of the Society of Glass Technology was held in Sheffield on Wednesday, April 18, the president, Professor W. E. S. Turner, D.Sc., in the chair. The formal business included the election of the following officers to fill the vacancies arising according to the "Constitution and Rules" of the society: President: Professor W. E. S. Turner, D.Sc. (re-elected). Vice-presidents: R. A. Coad-Pryor, B.A.; W. J. Gardner. Members of Council: F. F. S. Bryson, M.A., B.Sc., F.Inst.P.; Violet Dimbleby, B.Sc.; Major G. V. Evers; Colonel B. C. Halse; T. Teisen, B.Sc., C.E. Treasurer: Joseph Connolly (general); Wm. M. Clark, Ph.B. (American). Hon. Secretary: S. English, M.Sc. Auditors: Edward Meigh, M.Sc.; Dennis Wood, F.S.A.A.

The president's address on "The Year in Review in the World of Glassmaking" was taken as read, the main business of the meeting being a general discussion on "*Works Organisation.*" Mr. W. W. Warren (Messrs. Lemington Glassworks, Limited) opened the discussion with a paper entitled "*Organising for Production from Pot Furnaces,*" which had already been presented at the Newcastle meeting in February.

TANK FURNACE WORKS ORGANISATION.

The case for "Tank-Furnace Works Organisation" was presented by Mr. T. C. Moorehead (Messrs. United Glass Bottle Manufacturers, Limited), who said that organisation as applied to a manufacturing industry might be defined as a combination of men arranged or distributed in parts or groups with proper officials, managers and foremen, and so co-ordinated that they were able, with the aid of such machines and tools as they might have available, to produce a finished article efficiently. If they could not say assuredly that each of their groups was composed of capable men, each group in charge of a capable foreman, the foremen all capable, and co-operating under a capable superintendent or shift manager or head, whatever they might call him, who was responsible? He believed that the man really responsible for the losses in plant efficiency was the active head of the institution. He endorsed the opinion of industrial engineers and efficiency experts who stated that the average manufacturing plant had only 50 per cent. efficiency, and that also 80 per cent. of this tremendous loss of efficiency was due to the manager, or in other words, due to a lack of proper or efficient management. The difficulties, troubles or failures which beset the factory manager every day might all be traced back to inefficiency on the part of the management, and probably to three things: (1) Lack of foresight; (2) lack of thorough knowledge of the factory operations; (3) lack of initiative. The causes for these losses of efficiency could be grouped under five headings as follows: (1) Faulty raw material; (2) poor labour, that is, incapable, indifferent and disloyal employees; (3) poor attendance; (4) large labour turnover, or ratio of men leaving to the number of men on the pay roll; (5) machine or mechanical breakdowns. Mr. Moorehead went on to consider each of these headings in turn and to examine where organisation affected them.

1. *Faulty Raw Material.*—It was recommended that the buyer, or preferably a works chemist, should investigate the sources of supply to make provision for constant and regular supplies, keep a sufficient quantity in store at all times in order to ensure the factory against shutdowns in case of failure of deliveries, to analyse frequently the materials for purity, and to see that they came up to specifications.

2. *Poor Labour.*—This was a difficult problem and should be dealt with at the source. Provision should be made for carefully investigating every application for work in the plant, and the applicant should be interviewed by a man who is a good judge of human nature.

3. *Poor Attendance.*—It was a fundamental principle, in dealing with their difficult problems, to make a man's work interesting. This might be done first of all by being sure that the employees understood what they were doing and why. The more they knew about the material they worked with, the better. Weekly managers and foremen's meetings should be held, full and complete records or minutes being kept and copies circulated to those who were present. One copy of the minutes should be sent to the head office.

4. *Large Labour Turnover.*—To prevent the wastage due to this cause the work should be made agreeable. it was also necessary to regularise it or make it steady, and every man should be given identity. Make each feel that his progress was being watched and that interest was being taken in him. A great many manufacturing plants were going so far as to make a careful analysis of each job. The main idea, as was well known, was to study the contents of the job and find out what its requirements were, both with respect to physical strength and mental capacity. When this was done, the results were tabulated and printed on a card in the form of job specifications. Then, when new men were employed, they were selected so as to conform to these specifications and were adjusted to their positions in such a way as to make them contented with their surroundings and turn out the largest possible output commensurate with their wages.

5. *Machine or Mechanical Breakdowns.*—This was the least wearisome cause of loss of efficiency. In nine cases out of ten, machine breakdowns were due to lack of foresight; failure on the part of the man responsible for either the operation or upkeep of the particular machine to anticipate troubles; failure to see that spares for vital parts of the various machines were kept in store, and failure to keep all moving parts properly oiled and the machines clean, all of which brought us back to the human element and organisation.

Mr. Moorehead concluded his paper by emphasising the great responsibility that rests on the foremen, and gave some suggestions as to what questions a manager might ask himself in selecting his foreman or determining his capabilities.

Colonel S. C. Halse (Messrs. J. Lumb and Co., Limited) said that at his works after installing a set of new machines they had daily conferences, including everyone really concerned in the output of their machines. By analysing the figures obtained from day to day they had increased production very greatly and were able to trace very nearly every bottle dropped on to the conveyor.

PALESTINE MOTOR CAR IMPORTS.—According to the *Commercial Bulletin*, published by the Palestine Department of Commerce and Industry, 385 motor cars were imported into Palestine during 1922. Of this number approximately 95 per cent. came from the United States.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Pronounced activity continues at the basic furnaces in Sheffield and Rotherham. Makers of mild steel booked sufficient orders before values rose to their present level to occupy them for several months ahead. The whole of the output, roughly estimated to be equal to the pre-war average, is going into immediate consumption, and is finding an abundance of work for the rolling mills, which in April experienced one of the busiest months recently on record. New business, however, is not coming forward with anything like the freedom shown two months ago. The universal rise in pig-iron consequent upon the heavy shipments of blast-furnace coke and the home shortage of that commodity has forced steel prices up to a level that most users consider to be prohibitive having regard to the narrow margin of profit on finished goods. Buying has received a check. Consumers are hoping that an early improvement in the Continental position will produce a local easement, though steel-makers, with advanced costs to meet, show no disposition to make concessions from current rates, nor apparently do they entertain any fear that under the most favourable circumstances can Continental competition become a real factor in the immediate future. In the special steel section conditions, though far from satisfactory, are slowly brightening. Makers of commercial motor lorries and private cars are in the market for moderate tonnages of fittings and small castings. The promised improvement in the ship-building demand has not materialised, principally owing to the rise in raw and semi-finished materials. Railway carriage and wagon construction is an active feature. Sheffield is supplying an increased tonnage of axles, wheels and tyres to works at Nottingham and in the Midlands. Recent schemes of co-ordination have resulted in a valuable saving of works costs, and promise to attract substantial business in the early future. A careful watch is being kept on foreign constructional schemes which will require a heavy weight of those engineering products which Sheffield is specially equipped to supply. The light trades are looking to Colonial and South American markets for expansion in cheaper qualities of implements and tools.

South Yorkshire Coal Trade.—Sellers occupy a favourable position in every section with the exception of house-coal, the demand for which, unsatisfactory for several months, is still below the seasonal average. Exports continue a strong feature, though considerably more business could be done at lucrative prices if loading difficulties at the docks could be overcome. Full contract tonnages of best steams are going inland to the railways. The improved industrial demand leaves no surplus of cobbles and nuts. Washed slacks are in active demand at full rates. Coke is unchanged. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 18*s.* to 21*s.*; Yorkshire hards, 22*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 12*s.* to 14*s.*; nutty slacks, 10*s.* 6*d.* to 12*s.* 6*d.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Very little new is ascertainable concerning Cleveland pig-iron. Producers are well sold to the end of June, but there are now few inquiries circulating, and manufacturers are becoming keen to book orders to take the place of those that are rapidly being executed. Buyers are pursuing a most cautious policy, and as they anticipate further fall in values, notwithstanding continued high cost of output, they are not purchasing to any extent. The falling-off in demand is creating no small amount of anxiety, and at the moment prospects are far from encouraging. At the same time there is a feeling that the suspension of operations will be of short duration. Prices though hardly quotably changed tend downward. No. 1 is 130*s.*; No. 3 g.m.b., 125*s.*; No. 4 foundry, 122*s.* 6*d.*; and No. 4 forge, 117*s.* 6*d.*

Hematite.—There is next to nothing passing in East Coast hematite, values of which are distinctly easy. It is stated that makers would entertain forward business at below current rates, but customers are off the market at present. Nos. 1, 2 and 3 are quoted 122*s.* 6*d.*, and No. 1 is put at a shilling above mixed Nos.

Blast-Furnace Coke.—A good deal of complaint is heard of the scarcity of Durham blast-furnace coke, and the price for local use is advancing. For renewal of contracts with local regular customers the quotation is now in the neighbourhood of 44*s.* delivered.

Foreign Ore.—Inactivity still characterises foreign ore. Consumers have good stocks, and are well bought, so that they are not tempted by sellers' offers to accept 24*s.* 6*d.* c.i.f. Tees for best rubio.

Shipments of Iron and Steel.—Official returns give the total shipments of iron and steel from the Tees during the month of April at 116,858 tons, of which 54,836 tons were pig-iron, 3,915 tons were manufactured iron, and 58,508 tons were steel. With the exception of 4,448 tons of pig-iron loaded at Skinningrove, all the clearances were from the port of Middlesbrough. The most noteworthy fact in connection with the returns is that for the first time since before the war the monthly shipments of manufactured iron and steel exceed 60,000 tons. Of the 49,987 tons of pig-iron despatched from Middlesbrough 41,542 tons went abroad, and 8,445 tons went coastwise;

of the manufactured iron loaded 3,814 tons went abroad and 101 tons went coastwise; and of the steel shipped 48,274 tons went abroad and 10,234 tons went coastwise. Germany was the heaviest customer for pig-iron, taking 13,792 tons, and the United States was second with an import of 8,000 tons. India was again the largest buyer of both manufactured iron and steel, receiving 3,355 tons of the former and 17,780 tons of the latter.

Manufactured Iron and Steel.—In finished iron and steel a quieter feeling is noticeable. For several descriptions demand is falling off, but manufacturers are, as yet, very reluctant to make price concessions. Among the principal market quotations are:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 10*l.* steel billets (medium), 10*l.* 10*s.*; steel billets (hard), 10*l.* 15*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; heavy steel rails, 10*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 15*l.*; and galvanised corrugated sheets, 19*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A quieter tone is noticeable in the steel trade of Scotland this week, and although the lock-out of boiler-makers has barely had time to affect the steel industry it will very soon do so. Plant is still going steadily, but in one or two instances consumers are not desirous of taking in their usual deliveries for fear of a prolonged stoppage. The latter is not, however, anticipated, and an early settlement of the present difference is looked for. Inquiries show an easing off, particularly on home account, and while there are some very good lines now in the market for abroad the total foreign inquiry is not as large as it might be. With the shipbuilding trade so quiet there is less material being ordered for the yards in the way of plates, &c., but structural engineers are consuming fairly large quantities of their class of material. The demand for black sheets for abroad continues fairly good, but home users are not buying to any extent. Prices are all very firm and are nominally unchanged. The current quotations are as follows:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The state of the malleable-iron trade of the West of Scotland continues on even lines, and there has not been much change as yet, but fresh business is not too plentiful this week. Bookings will account for most of the output for a bit ahead, but deliveries will ease off very soon if the present labour trouble continues. In the steel re-rolling branch quite a lot of business is passing. The price of "Crown" bars keeps firm at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—While there is still a fair amount of activity in the Scottish pig-iron trade, a falling-off is noticeable in the inquiry, and foreign buyers are not so plentiful. Conditions at the works are quite good meantime, but makers prefer to be well booked forward. Steel-makers have been taking in very good deliveries of hematite up to date, but the future is a trifle uncertain. The price to-day is 6*l.* 7*s.* 6*d.* per ton delivered at the steel works. The tone is inclined to become easier in foundry grades, and although shipments abroad are being fairly well maintained a dullness prevails. Prices are without quotable change at 6*l.* 2*s.* 6*d.* per ton for No. 1 and 5*l.* 17*s.* 6*d.* per ton for No. 3 quality delivered Glasgow.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from the Port of Glasgow for the week ending last Saturday, April 28, amounted to 3,872 tons. Of that total 3,780 tons went foreign and the small balance of 92 tons went coastwise. For the same week last year the figures were 1,188 tons foreign and 136 tons coastwise.

Scottish Shipbuilding.—A fair amount of activity has been general in the Scottish shipyards during recent months and the figures of the tonnage launched last month bear that out. Over the different districts there were launched 17 vessels of a total of 55,537 tons, which is quite a satisfactory output with trade conditions as they are. The details are:—

	April, 1923.		Four Months, 1923.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	15	51,731	35	119,935
The Forth	1	2,606	7	7,598
The Tay	1	1,200	2	9,200
The Dee and Moray Firth	—	—	3	2,190
Totals	17	55,537	47	138,923

The Clyde figures for the past month are a very good average for the month of April and are nearly equal to the combined totals for the two previous months, although comparing badly with the record of over 119,000 tons for April, 1913. The Clyde total output for the year to date is 35 vessels of 119,935 tons, which is only a shade better than the one month quoted above, but it shows nevertheless that conditions have recently been on an improving basis. The inevitable "fly in the ointment" has, however, most unfortunately arrived, and now we have the boilermakers in all the federated yards locked out as from Monday of this week. The result of their refusal to accept the terms agreed to by the federated trades in the matter of overtime and nightshifts has caused a complete dislocation all round, and other tradesmen will gradually require to cease work as all employed in the yards are dependent upon one another. Repair work is already being diverted to the Continent and inquiries for new vessels will be hung up as builders cannot possibly name a date when delivery could be made.

NOTICES OF MEETINGS.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, May 4, at 7.15 p.m., in the University College, Singleton Park, Swansea. Annual General Meeting.

THE INSTITUTION OF CIVIL ENGINEERS.—Friday, May 4, at 6 p.m. The twenty-ninth James Forrest Lecture, entitled, "The Interdependence of Abstract Science and Engineering," by Sir Richard T. Glazebrook, K.C.B., F.R.S., Hon.M.Inst.C.E.

THE INSTITUTION OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, May 5, at 4 p.m., at the College of Technology, Manchester. Annual Business Meeting. Discussion on "The Training of the Future Foundryman, Relating Particularly to the Difference between the Moulder and the Coremaker," will be opened by Mr. T. Makemson.

THE INSTITUTE OF TRANSPORT.—Monday, May 7, at 5.30 p.m., in the Lecture Theatre of the Institution of Electrical Engineers, Victoria Embankment, W.C. 2, when a paper will be read on "The Investigation of the Financial Prospects of Railway Electrification," by Sir Philip Dawson, M.P.

THE SURVEYORS' INSTITUTION.—Monday, May 7, in the Lecture Hall of the Institution, when a paper will be read by Mr. C. H. Bedells (Member of Council), entitled "Some Functions of a Surveyor under the Settled Land Acts, 1882–1890 and Part II of the Law of Property Act, 1922." The chair will be taken at 8 p.m.

THE ROYAL SOCIETY OF ARTS.—Monday, May 7, at 8 p.m.: Howard Lecture. "The Development of the Steam Turbine," by Mr. Stanley S. Cook, B.A.(Cantab.), M.I.N.A., M.I.M. (Parsons Marine Steam Turbine Company) (Lecture II). Wednesday, May 9, at 8 p.m.: Ordinary Meeting, "Surface Combustion—With Special Reference to Recent Developments in Radiophragm Heating," by Professor William A. Bone, D.Sc., Ph.D., F.R.S. An experimental demonstration of "Radiophragm" heating will be given by Mr. F. J. Cox, M.Inst.M.E.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, May 8, at the House of the Royal Society of Arts, John-street, Adelphi, the following paper will be read: "Heavy Grade Egyptian Crude Petroleum," by Mr. W. A. Guthrie, F.I.C., F.R.S.E., M.Inst.P.T., &c. The chair will be taken at 5.30 p.m. by the president, Mr. H. Barringer, M.Inst.C.E.

THE INSTITUTION OF STRUCTURAL ENGINEERS, LANCASHIRE AND CHESHIRE BRANCH.—Wednesday, May 9, at 7.15 p.m., at Lecture Room, Whitworth Engineering Laboratories, Victoria University, Coupland-street, Manchester. Paper on "Education of a Structural Engineer," by Mr. H. W. Clapham, B.Sc.(London).

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, May 10, at 6 p.m., presentation of the Faraday Medal to the Hon. Sir Charles A. Parsons. The Fourteenth Kelvin Lecture, "Problems in Telephony, Solved and Unsolved," by Dr. J. A. Fleming, F.P.S., Honorary Member.

THE IRON AND STEEL INSTITUTE.—Thursday and Friday, May 10 and 11, at 10 a.m., at the Institution of Civil Engineers, Great George-street, S.W. 1. Annual Meeting. Thursday, May 10, at 10 a.m.: General Meeting. Presentation of the Bessemer Medal to Dr. W. H. Maw. Papers to be read and discussed: "The Reactivity of Coke as a Factor in the Fuel Economy of the Blast Furnace," by Mr. E. R. Sutcliffe and Mr. E. C. Evans; "British Steel Works Gas Producer Practice," by Mr. F. Clements; "Some Characteristics of Moulding Sands and their Graphical Representation," by Mr. J. E. Fletcher; "Some Observations on the Effect of Small Quantities of Tin in Steel," by Mr. J. H. Whiteley and Mr. A. Braithwaite; "A Note on Temper Carbon," by Mr. L. Northcott; "Change of Density of Iron due to Overstrain," by Mr. J. W. Landon. Thursday afternoon, at 2.30 p.m.: "The Production of Single Metallic Crystals and Some of their Properties," by Mr. H. C. H. Carpenter, F.R.S.; "On the co-relation of the Chemical Constitutions of 'True Steels' to their Micrographic Structures," by Mr. J. O. Arnold, F.R.S.; "The Constitution of the Alloys of Iron and Steel," by Mr. D. Hanson and Mr. J. R. Freeman; "The Potential Energy of Cold-Worked Steel," by Mr. T. F. Russell; "The Changes in Iron and Steel below 400 Deg. C.," by Mr. F. C. Thompson and Mr. A. Goffey; "Some Experiments on Grain-Growth in Iron and Steel," by Mr. L. E. Benson and Mr. F. C. Thompson. Thursday evening, at 7 p.m. for 7.30 p.m.: Annual Dinner in the Grand Hall, Connaught Rooms, Great Queen-street, W.C. 2. Friday, at 10 a.m.: "Economic Principles Governing the Use of Electrical Power in Iron and Steel Works," by Mr. C. A. Ablett; "The Constitution of Basic Slags—Its Relation to Furnace Reactions," by Mr. T. P. Colclough; "Some Properties of Steels containing Globular Cementite," by Mr. C. H. Desch and Mr. A. T. Roberts; "The Structural Constitution of Iron-Carbon-Silicon Alloys," by Mr. K. Honda and Mr. T. Murakami; "Some Investigations on the Quenching of Carbon Steels," by Mr. T. Matsushita; "Note on a Value for the Surface Tension of Iron Sulphide," by Mr. E. J. L. Holman. Friday afternoon, at 2.30 p.m.: "A Contribution to the Study of Hardness," by Mr. C. A. Edwards and Mr. C. R. Austin; "An Investigation of the Behaviour of Certain Steels under Impact at Different Temperatures," by Mr. F. C. Langenberg; "The Cold-Working of Steel with Reference to the Tensile Test," by Mr. J. Stead; "The Acl Range in Alloy Steels," by Mr. J. J. A. Jones; "Some Mechanical Properties of a Series of Chromium Steels," by Mr. C. R. Austin; "Variation of Brinell Hardness Number with Testing Load," by Mr. H. O'Neill.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, May 11, at 6.30 p.m., at the Engineers' Club, Coventry Street, W. 1. Lecture on "Low-Power Flying," by Major M. E. A. Wright, A.F.C.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 11, at 7.30 p.m., at 39, Victoria-street. Ordinary Meeting: Durham Bursar's Lecture, "The Theory of Resistance to the Flow of Gases and Fluids in Pipes," by Mr. W. F. C. Cooper, B.Sc. (Member).

INSTITUTION OF ENGINEERING INSPECTION.—Friday, May 11, at 7.30 p.m., in the Rooms of the Society of Arts, John-street, Adelphi, a paper will be read by Mr. H. J. Davey, M.B.E., entitled "Some Notes on 'Ciment Fondu,' with Results of Chemical Analyses," by Mr. H. F. Knight, F.I.C.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 11, at 9 p.m., at Albemarle-street, Piccadilly, W. 1. Evening discourse will be delivered by Professor William Arthur Bone, D.Sc., F.R.S., on "Gaseous Combustion at High Pressures (New Experiments)." Afternoon Lecture at 3 p.m.: Thursday, May 10, Professor J. T. MacGregor-Morris, M.I.E.E., on "Modern Electric Lamps: (III) Glowing Gases (Neon Lamps)."

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—An agreement has at last been reached by representatives of the employers and the coal trimmers and tippers for extending the working hours at the South Wales ports. Negotiations have been proceeding for some weeks past, and the position became so acute that a court of inquiry under the Industrial Courts Act was set up to go into the matter. The court sat and took the evidence of the employers, and then adjourned so that direct negotiations might again be resumed. As a result a provisional agreement was reached, but the men by a majority refused to accept the terms of the agreement. Since then further conferences have taken place, and as a result agreement has been reached on the basis of the provisional agreement which is subject to certain reservations. The delegates of the coal trimmers and tippers, who were given plenary powers in the matter, have accepted the principle of a third shift of work to the extent required by the employers in consultation with the workmen. Until May 22, 33⅓ above the day tariff is to be paid for night work and the present tariff is to remain in operation until June 30, 1924. No extra payment will be made for night work after May 22 next. It had been hoped that the wages of the colliery workers in May and June would have been raised above the minimum of 28 per cent. above the 1915 standard. The joint audit for the coal trade for January and February, however, certifies a wage rate of 26·05 per cent., or 1·95 per cent. below the minimum which the owners are able to pay only by the sacrifice of 71,519*l.* of their profits. After allowing for the cost of standard wages, other costs, and the owners' standard profits, the surplus available in January and February was 854,608*l.*, compared with 313,267*l.* in November and December last. The output of coal in January was the highest reached in any month since the war, and the production in the two months of January and February was greater than in any two months since the operation of the present national agreement. The cost of production was lessened by 5½*d.* per ton, of which 2*d.* represented labour cost and 3½*d.* "other costs," and selling prices were on the average 10*d.* higher. An interesting opinion was expressed by Mr. W. North-Lewis, chairman of Insoles, Limited, and the Windsor Steam Coal Company (1901), Limited, at a meeting of the Chamber of Commerce held yesterday. He said he could not help feeling that it would be wise on the part of directors of colliery companies to discourage, or at all events, not to encourage their sales agents to squeeze the last farthing out of the buyer when they had the market absolutely at their mercy, as had been the case in the past couple of months. He was not at all sure that the excessively high prices would be to the ultimate good of the coal trade. It was, however, very difficult, when the demand overtopped the supply to keep prices down, but having recently travelled about the Continent he did feel that they were doing themselves no ultimate good in pressing prices unnecessarily high. The Tredegar Iron and Coal Company, Limited, which was registered in March, 1873, and possesses collieries in Monmouthshire has decided to capitalise its reserves and issue two new 1*l.* shares, fully paid, for each 5*l.* of capital held in the company. As the capital of the company amounts to 1,236,502*l.* the proposal represents a distribution of 494,601*l.* in shares.

PERSONAL.—Messrs. Alfred Herbert, Limited, Coventry, have removed their Manchester branch office to Wrendal House, 2, Whitworth-street-west, Manchester, from 30, Cross-street.—The Clyde Oil Fuel System, Limited, have transferred their London office from 47, Victoria-street, S.W. 1, to 37, Walbrook, E.C. 4.—The St. Helens Cable and Rubber Company, Limited, is shortly to leave Warrington for Slough. The new site at Slough consists of a factory already erected, which, with the land adjoining, amounts to about 200,000 sq. ft. This is considerably more than the present works area, which has been too small, for some time past, to enable the company's business to be dealt with as promptly as desired.—Mr. Arthur Marks, F.I.C., A.R.C.Sc., A.R.S.M., who has been for the past seven years metallurgist and head of the testing department of Messrs. Harland and Wolff, Limited, Belfast, has resigned his position for reasons of health, and has been appointed metallurgical adviser to Messrs. A. Harper, Sons and Bean, Limited, Dudley, Tipton and Smethwick.

REINFORCED CONCRETE SYPHON UNDER THE MIDDLE HARBOUR, SYDNEY, N.S.W

(*For Description, see Page* 547.)

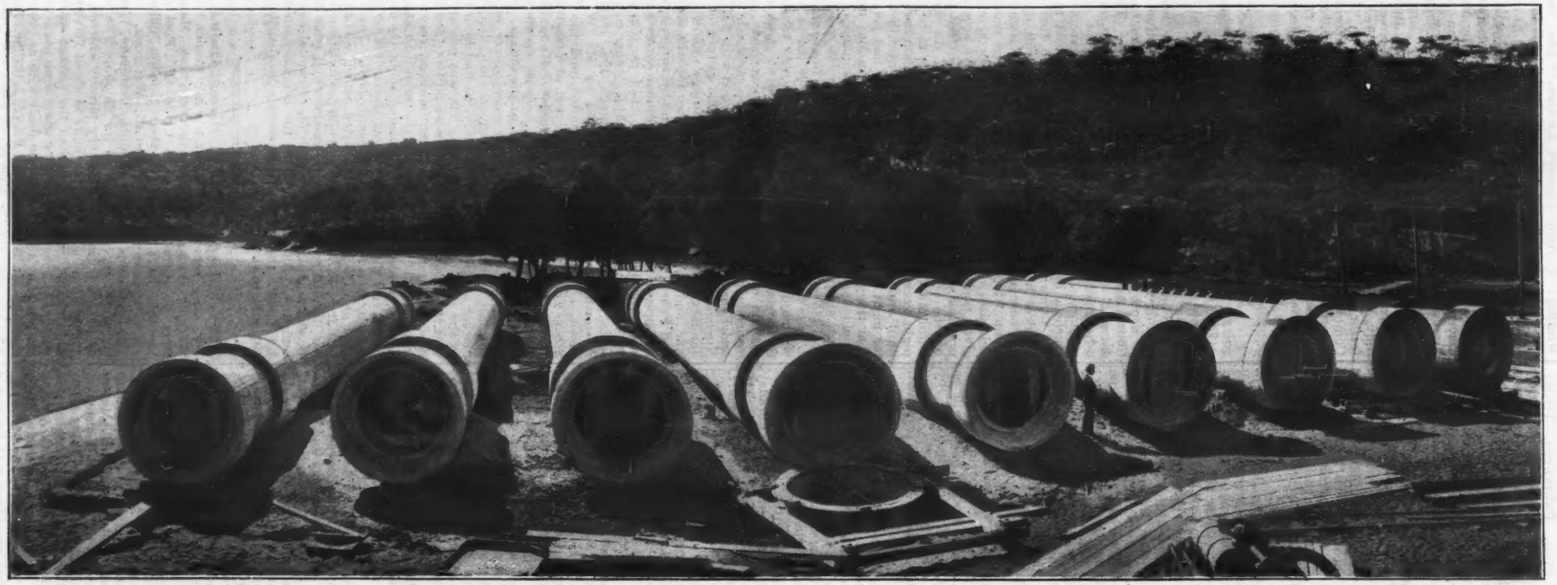


FIG. 16. 6-FT. REINFORCED CONCRETE PIPES, 100 FT. LONG, AT THE MOULDING YARD.

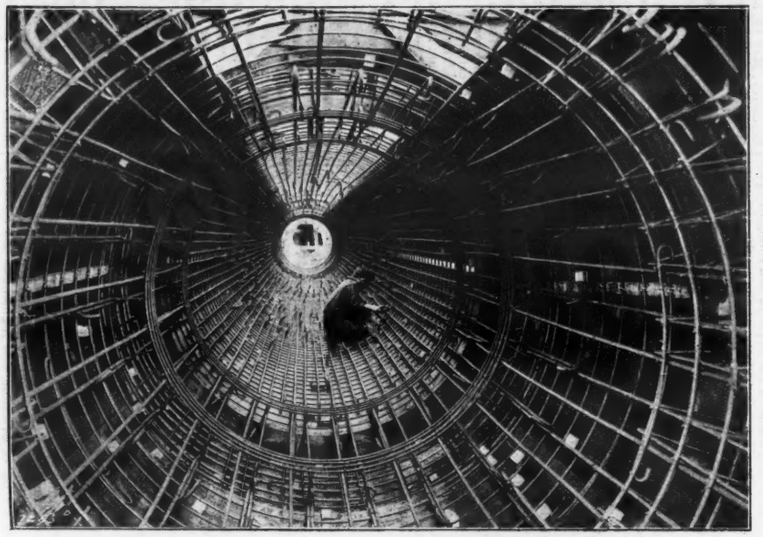


FIG. 17. INTERIOR OF 6-FT. PIPE SHOWING REINFORCEMENT.

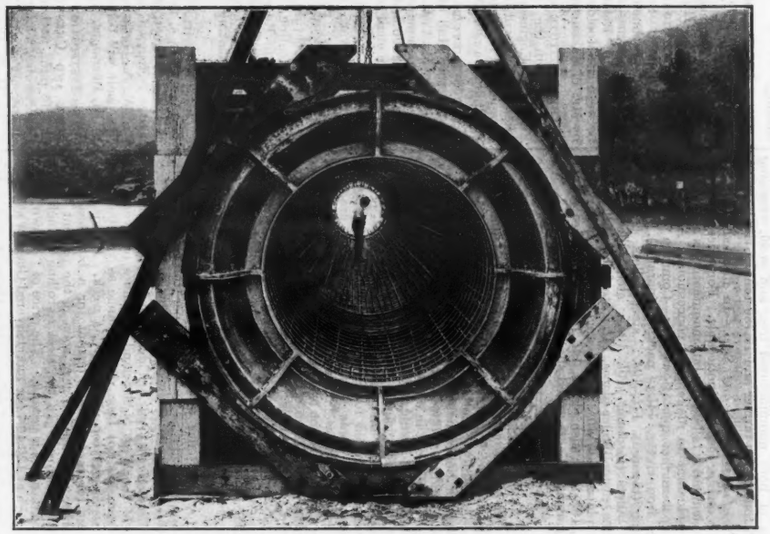


FIG. 18. END OF PIPE SHOWING MOULDS FOR SOCKET.

Fig. 17. Interior of 6-Ft. Pipe showing Reinforcement.

Fig. 18. End of Pipe showing Moulds for Socket.

5,000-KILOWATT BRUSH-LJUNGST

CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING CO

(For Description, see Pag

Fig. 2.

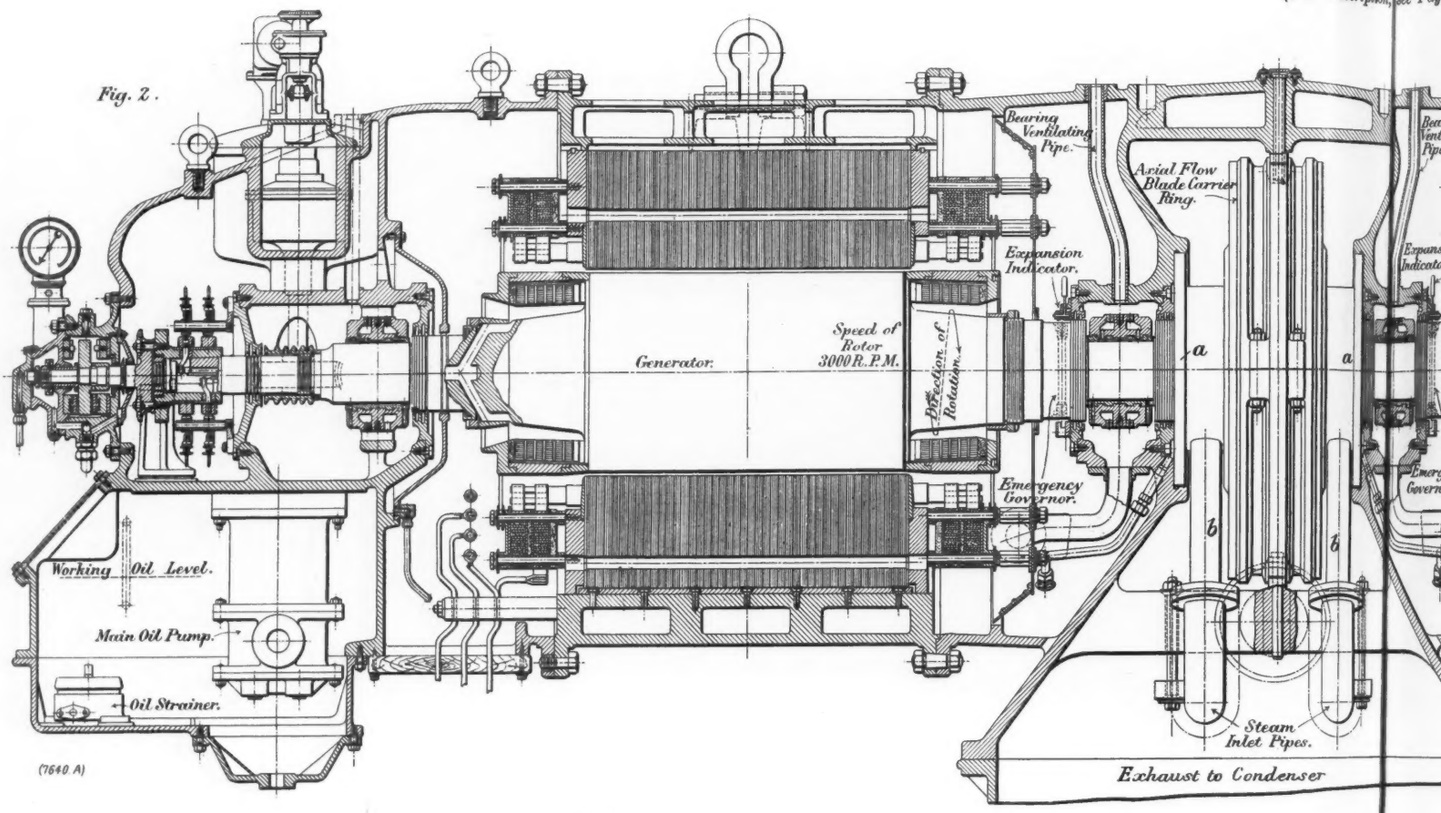


Fig. 3.

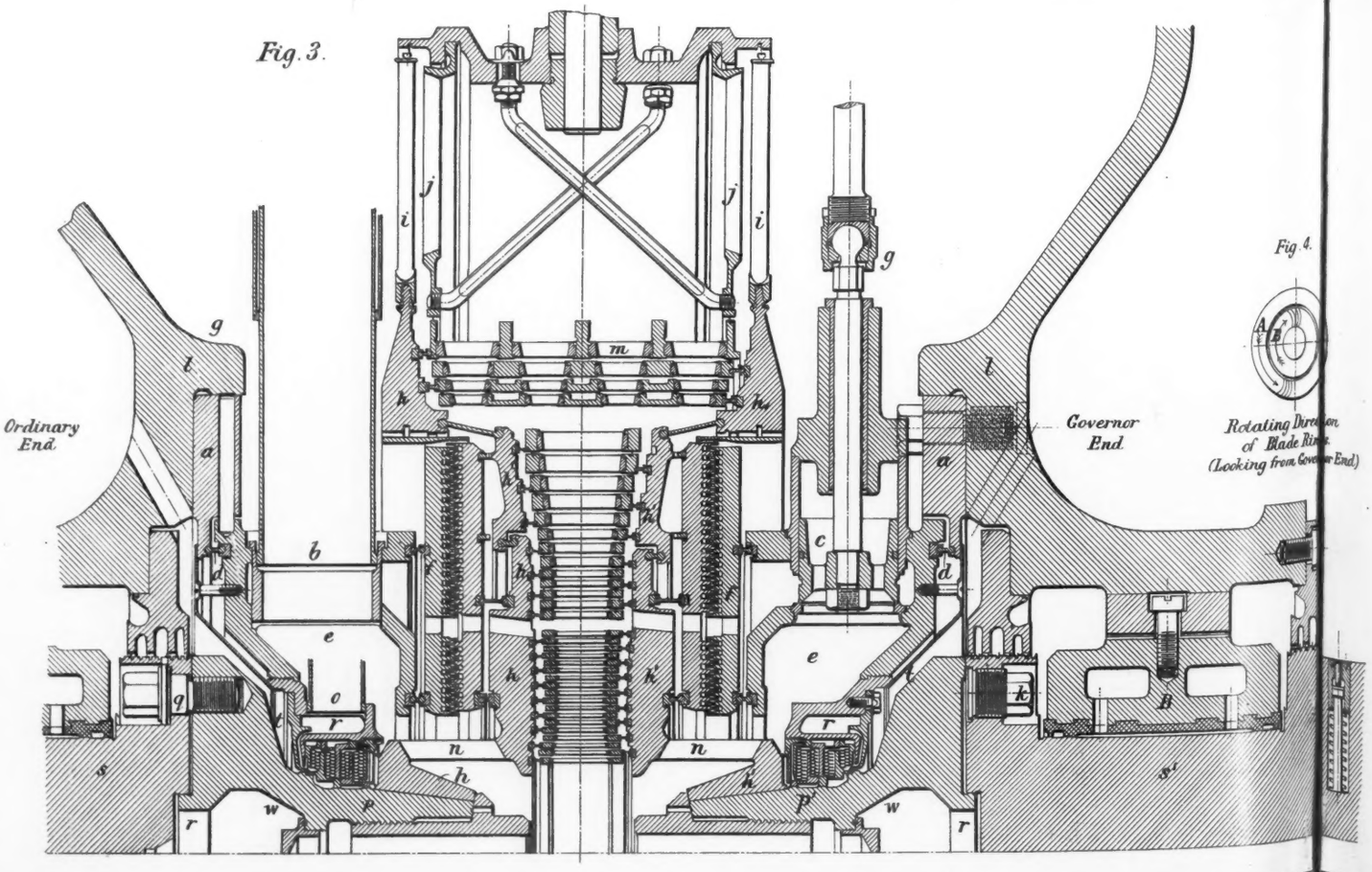


Fig. 4.

H-LJUNGSTRÖM STEAM TURBINE.

ENGINEERING COMPANY, LIMITED, ENGINEERS, LOUGHBOROUGH.

(For Description, see Page 542.)

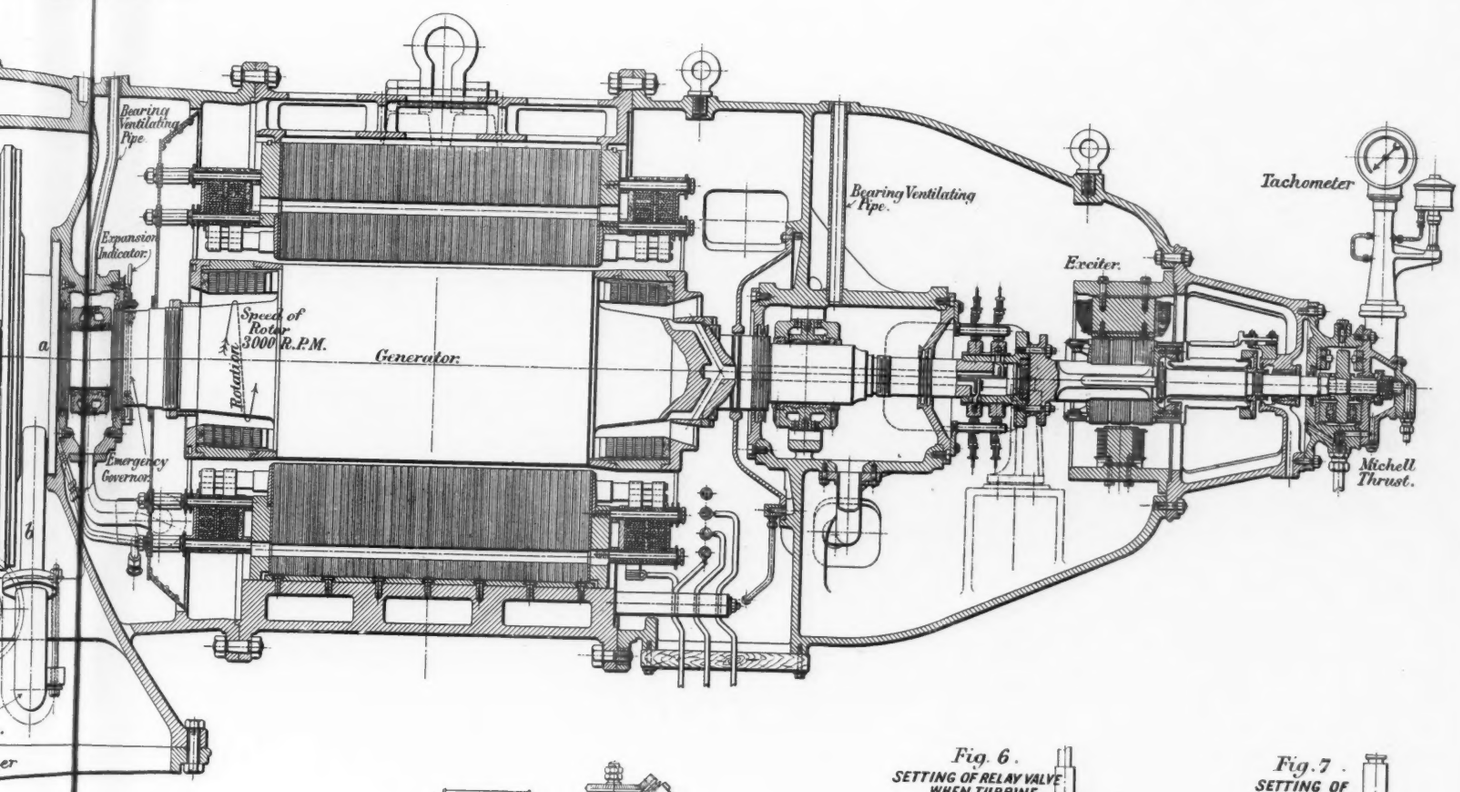


Fig. 4.

Fig. 5. SECTION THROUGH MAIN GOVERNOR DRIVE.

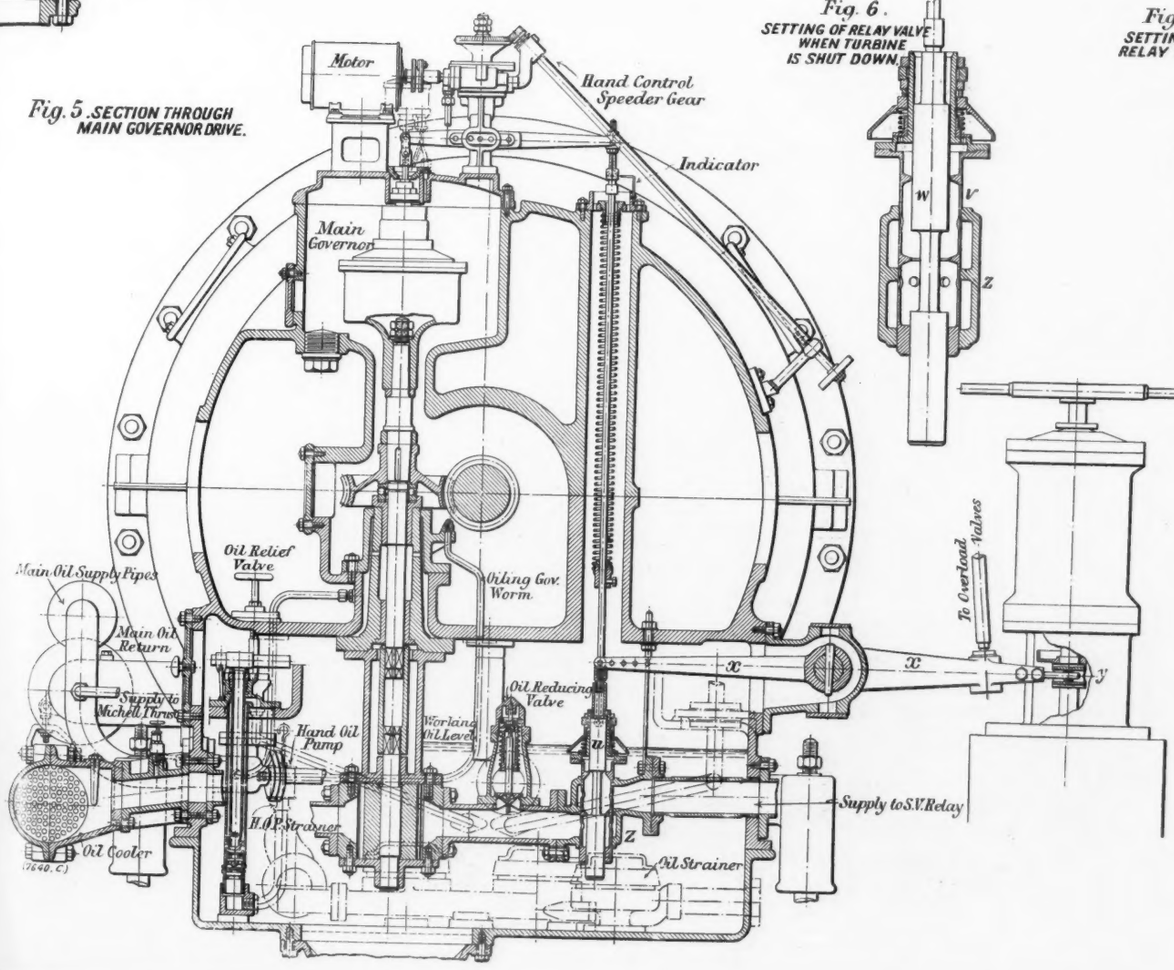
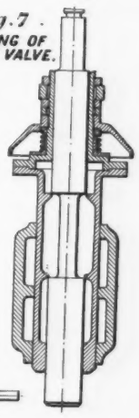


Fig. 6. SETTING OF RELAY VALVE WHEN TURBINE IS SHUT DOWN.

Fig. 7. SETTING OF RELAY VALVE.



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UNITED STATES : For subscription, New York ; W. H. Wiley 432, Fourth Avenue. For Advertisements : J. S. Allan 30, Church-street, New York.

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ENGINEERING.

FRIDAY, MAY 4, 1923.

BREAKDOWNS IN POWER PLANTS.

IT is a serious matter for an electricity undertaking to suffer any interruption of its supply. However brief the stoppage may be, it is a cause of inconvenience to hundreds of people and a subject of adverse comment by thousands more. Lights are out, tramcars immovable, lifts suspended in mid-air, machines at a standstill with work or material in them, and a large proportion of the comforts or necessities of life withdrawn for the time being. Occurrences of this nature are, fortunately, extremely rare, and the public has been trained to rely upon a continuity of service comparable with that of gas and water, although the difficulties of maintaining such a service, in the case of electricity, are immeasurably greater. Every station engineer of experience could tell tales of almost incredible happenings of which nothing was known outside the station beyond possibly a momentary flicker of the lamps. Sometimes it is a case of sudden emergency when every second counts and there is no time either for reflection or mistakes, as when a new unit has to be rushed into service, with all its auxiliaries, to take the load from one which is failing. At other times there is the even worse strain on the staff of getting through a peak load with steam pressure falling and temperatures rising, and the whole station depending upon the continued service of some piece of apparatus which it is not safe to run at all. The experience of Kipling's heroes of the "Bolivar" who, having done everything they could, accepted the situation philosophically and "betted when she'd break" must have been read with sympathy by many a central station engineer.

When it is remembered that trouble on the mains or in sub-stations is equally capable of causing interruptions of supply with accidents in the generating station itself, the small total number of interruptions experienced by the public is seen to be all the more creditable to the station operation. But with the increasing magnitude of stations and of the areas they serve, the effects of central-station stoppages become more important, and almost no precautions can be considered too great if they tend to safeguard the absolute continuity of service. When trouble of the kind which causes an interruption of supply occurs in a power station it does not usually arise from the main generating units. These are under constant surveillance and nothing short of mechanical disaster is likely to put one of them out of commission without sufficient warning to enable another machine to be got into service to take the load. The proper functioning of the whole station, however, depends on a great variety of auxiliary machinery, the stoppage of any part of which reacts with more or less suddenness and intensity upon the main generating sets. All this machinery, in turn, depends upon the steam, or electric power, generated in the station, so that the problem of providing for the continuance of this all-important auxiliary power under all circumstances is one of the fundamental questions in the design of large power stations.

The subject was brought forward for discussion at the meeting of the Institution of Electrical Engineers last week by Messrs. L. Breach and H. Midgley, who read a joint paper on "The Drive of Power Station Auxiliaries." The authors took the case of a modern station, with five main units, each of 25,000-kw. capacity, and considered seven different schemes for providing power for such auxiliaries as circulating pumps, air pumps, condensate pumps, fans, stokers and feed pumps. The turbine auxiliaries, under which heading the first three of these are comprised, are completely duplicated in every scheme, a practice which is quite justified where such large main units are under consideration. In three of the schemes, however, one of the alternative sources of power for these motors is a special alternator or direct-current machine, driven by an extension of the main generator shaft. Most engineers, we think, will agree with Mr. W. E. Highfields' remarks in the discussion, namely, that turbo-generators are quite long enough now, and the coupling on of another machine introduces difficulties of alignment and balance that might well be avoided, quite apart from the disadvantageous conditions as regards electrical design. The authors did not specially advocate any one of their schemes, and they pointed out, indeed, that a combination of the features of two or more schemes might be desirable in certain cases. In this respect the paper was rather disappointing, and the discussion which ensued was hardly worthy of the importance of the subject. Several men were present whose first-hand experience of actual operating difficulties must have caused them to hold very definite opinions as to the advantages or otherwise of certain lay-outs, but they refrained, in general, from expressing them. Some of the speakers, indeed, must have been able from their own knowledge to mention instance after instance of power-station interruption and to have given the real causes. Information as to what kind of things do happen to cause failure of the supply in ordinary working would have been very much to the point in the discussion of such a paper as that before the meeting, and would have raised it to a definitely practical plane.

The extent of the ground covered by the paper makes detailed comment almost impossible. In general the authors seek security in duplication of apparatus and provide that the alternative auxiliaries are driven from sources quite independent of each other. This is very sound from one point of view, but unless carried out with discretion it is liable to conflict with the requirements of simplicity and interchangeability. It may seem safer to drive one circulating pump of a pair by a direct-current motor and the other by an alternating-current motor, but the scheme destroys interchangeability and involves unnecessary duplication of spares. A very good rule in a power station is to have all motors of the same type and make, and of as few different sizes as possible. This will, no doubt, involve unnecessarily large motors for certain purposes, but the ease with which any motor or starting switch can be replaced by another which is not in use, and the fewness of the spares which have to be carried, will more than compensate for the disadvantages. Standardisation along these lines, of course, necessitates a decision as to whether alternating current or direct-current motors shall be adopted, and the simplicity of the former is somewhat counterbalanced by the fact that in

cases of emergency, they cannot be supplied from a battery without the intervention of a motor generator, and speed regulation is also more difficult.

The use of steam-driven auxiliaries, comforting though their presence is in time of trouble on the electrical system, is taking a smaller and smaller place in power-station economics. Steam-driven circulating pumps and air pumps are somewhat of a nuisance in a condenser pit and the use of steam-driven auxiliaries generally is almost incompatible with a high operating efficiency of the station. We were able some few years ago to publish the operating results of a station of about 12,000,000 kw.-hours capacity, in which steam-driven auxiliaries were almost exclusively used. The steam taken by the main generators per 8-hour shift was given by the equation $S = 48{,}000 + 13{\cdot}35\ K$, in which K denotes the electrical output in kilowatt-hours during the shift. The water pumped into the boilers during the same period was $W = 110{,}000 + 17\ K$, the difference amounting to $62{,}000 + 3{\cdot}65\ K$, being mostly represented by the consumption of the auxiliaries. Few stations are probably as bad as this; but, on the other hand, few are in a position to discriminate between the consumption of the main generators and that of the auxiliaries, so that there are no means of knowing how inefficient the latter really are.

In considering the question of steam-driven auxiliaries the necessity of being able to start up a station again promptly after a total shut-down must not be forgotten. At least one exciter and one circulating pump and one air pump must be got going before any main generator can be got on the bars. Unless a battery is available in such an emergency, some steam-driven machinery independent of the main generators is absolutely necessary. The modern tendency is to provide a steam-driven "house generating set" to furnish the necessary starting current for the station, such a set also forming a useful standby, capable, itself, of being started independently of the functions of any electrical apparatus. The one kind of auxiliary machinery which we think engineers would at all times prefer to be steam driven is the boiler-feed pumps. The authors of the paper to which we have referred, suggest for every one of their seven schemes one electrically driven feed pump and one steam-driven feed pump, for each group of six boilers, either pump being capable of serving the whole of the boilers in the group. The power taken by a boiler feed pump is so small that efficiency is quite a secondary consideration, especially as the exhaust steam can generally be made full use of. The maintenance of the feed supply is, however, so absolutely vital, that the security afforded by duplicated steam pumps and piping is much to be preferred to any method involving electrical driving. As the boilers are naturally close at hand, it is much better to take steam direct from them to the pumps, than to rely upon the proper functioning of all the machinery, cables, and electrical apparatus required for the provision of electric current.

So far as any single rule applies to the layout and design of auxiliary machinery in a power station, it is that simplicity, straightforwardness and visibility of apparatus are above all things to be desired. Things that are in full view and easy of access rarely go wrong, and if they do there is often sufficient warning to enable serious trouble to be averted. Even duplication of apparatus can be carried to excess, and it is so carried when complicated operating conditions are introduced. Every unnecessary item of apparatus or yard of cable may as well be a cause of trouble as a safeguard against it. The fewer things to go wrong, the less numerous will be the breakdowns.

Moreover, when an accident does occur, a dozen alternative methods of operation are no better than one, and "Hobson's Choice" is sufficient. The disconcerting moments of a breakdown are those seconds or fractions of a second during which the mind is endeavouring to grasp exactly what has occurred and how the situation has to be dealt with. There is no time for reflection, immediate action is imperative and the simpler and more obvious the arrangement of the plant, the more likely is the correct action to be instinctively made, and further disaster possibly averted.

THE DISPUTE IN THE SHIPBUILDING INDUSTRY.

THE want of brotherliness between the brethren of a certain trade union was the subject of caustic comment by Mr. Justice Coleridge in a recent judgment which has attracted much attention. There have been regrettable differences on occasion between brothers since the days of Cain and Abel, but the differences between certain of the unions which make up the brotherhood of the Federation of Engineering and Shipbuilding Trades, and the federation itself, on the subject of the overtime and nightshift agreement recently concluded between that federation and the Shipbuilding Employers' Federation, is likely to have disastrous results on the shipbuilding industry just when there were hopes of its revival. After protracted negotiations the Shipbuilding Employers' Federation and the Federation of Engineering and Shipbuilding Trades entered into an agreement as recently as March 22 on the subject of overtime and nightshift. It was to run for a period of three years, and was entered into after a ballot vote had been taken of the constituent unions, with the exception of the United Society of Boilermakers and Iron and Steel Shipbuilders, the Amalgamated Society of Woodworkers, and the United Operative Plumbers and Domestic Engineers' Association. The Boilermakers' Society apparently preferred district agreements, with regard to overtime and nightshift, to a national agreement, and their Executive state that the Society took no part with the Shipbuilding and Engineering Trades Federation in the drafting of the agreement, and made it clear throughout all the negotiations that they could be parties only to district agreements in these matters.

However this may be, the agreement was entered into, we understand, by the federation as representing all its constituent unions, but the Joiners', the Plumbers' and the Boilermakers' Societies have repudiated it. The shipbuilding employers' view is clearly stated in their letter to Mr. Ramsay Macdonald, in which they state: "The Federation of Engineering and Shipbuilding Trades, with whom we have had exhaustive consultations in regard to the position and attitude of the Boilermakers' Society, have been fully acquainted with this federation's view that if collective bargaining is to be usefully maintained in industry, the constituent members must honour agreements negotiated and completed between the parent organisations. The Federation of Engineering and Shipbuilding Trades appreciate and accept this principle, but in the present instance the difficulty is that one of their members, the Boilermakers' Society, refuses to be bound by an agreement negotiated by them." Collective bargaining is one of the main objects for which trade unions—and, it may be assumed, federations of trade unions—were formed, and the value of national agreements between federations of employers and federations of workers or of trade unions would be heavily discounted—if not altogether destroyed—if a dissentient minority on either side, while remaining in the federation which negotiated the agreement on its behalf, were to be allowed to repudiate the agreement and treat it as naught. It is true that the Executive of the Boilermakers' Society have given six months' notice to their federation of their intention to withdraw from the federation, and their members are to ballot on the question of the proposed withdrawal.

In the meantime, however, the society is a part of the federation and should honour the agreement entered into on its behalf. Their refusal to do so made it necessary for the Employers' Federation to intimate that employment would not be available for the members of the society after April 30. As a result of the dispute many thousands of men—the number is variously estimated at from 10,000 to 30,000—are already out of employment, and no doubt the number will increase from day to day as the effects of the stoppage are increasingly felt. Shipbuilding will be delayed, and ship-repairing will be diverted to the Continent, and it is impossible to estimate the probable set-back to the shipbuilding industry as a whole.

Meantime the lock-out notices have been suspended for this week as regards the other two dissentient societies because they have agreed to hold a ballot on the question of honouring the agreement and to work under it in the meantime under protest. It is to be hoped that their members will listen to reason before it is too late.

THE INDUSTRIAL FATIGUE RESEARCH BOARD.

THE third annual report of the Industrial Fatigue Research Board, covering a period of 15 months to the end of last year, contains some information that will be of interest to engineers, and suggests still more that may come to be so. The depressed industrial period to which the report relates has done what it could to handicap and discourage the Board's activities. Men's minds, occupied with the most urgent economic problems, have been little disposed to investigate means for increasing the amenities of industrial life, or even for improving its efficiency, and, except for an investigation undertaken in co-operation with the Glass Research Association, the Board has taken no definite steps to collaborate with any industries, and is not likely to do so till times are more favourable than they were when the report was written. The circumstances of the time have, indeed, provided unhappy opportunity for investigating the relation of industrial depression to fatigue and efficiency. Some knowledge on the point has been gained in the cotton industry, and more might probably have been collected had the Board enjoyed larger resources. But for the most part the succession of short time and constant change of work, which was necessary in order to make the most of such business as was available, made the period singularly unsuitable for seeking those uniformities between fatigue and its factors which constant change of conditions tend to mask.

Nevertheless, the period has by no means been sterile. An important part of the Board's work is conducted in the laboratory on material that is not affected by the state of trade; and in the period under review considerably more seems to have been done in this branch of work than in previous years, and results obtained that may be of permanent importance. It is, indeed, in such work that the Board appears at present to be most strongly staffed. So far as it is content to restrict its activities to investigations and researches in pure or, at least, academic science—a restriction that must greatly limit their possible usefulness—its work can have no higher credentials than those offered by the constitution of the Board and its scientific committees. Many of the researches that have been instituted are still in progress, but in addition to what may be hoped from their completion, definite results have already been obtained, especially in three important researches relating to muscular work of different kinds.

One of these was devoted to observing the rate of recovery after exercise, in which definite relations were found to exist between speed of movement, consumption of oxygen and rate of recovery. With horizontal walking and running—*i.e.*, muscular movement involving no appreciable external work—the consumption of oxygen below a certain speed of movement increased approximately as the square of the speed, but did not increase as the movement became faster, thus appearing to show that the capacity of the lungs and heart to supply oxygen to the tissues sets a limit to the rate at which oxygen is consumed, and establishes a sharp line of demarcation between the extent of exercise from which recovery is currently made and that from which it is not. With muscular movements involving external work there is an optimum speed for which efficiency reaches a maximum, which is given as 25 per cent.; though doubtless this figure may be the subject of further investigation before it is accepted generally. From the beginning of exercise of any kind the body loses oxygen to an extent depending on the severity of the exercise, and the deficit of oxygen is maintained until recovery begins at the end of the exercise. Most of the loss is recovered within a few minutes of ceasing. For rates of energy expenditure within the capacity of the lungs and heart to supply oxygen to the tissues the deficit of oxygen remains constant for a given speed, however prolonged may be the exercise, and

increases only with increase of speed, the total excess oxygen supplied during recovery being equal to this deficit. So far, therefore, as concerns the muscular machine, such exercise might be kept up indefinitely; but for rates of working beyond the capacity of the lungs and heart the deficit of oxygen increases with the time, and lactic acid accumulates until exhaustion sets in. Accordingly, the research appears to disclose a method for determining for any exercise the limiting speed up to which it can be carried on without causing the accumulation of waste products and consequent exhaustion.

Another similar prospect of success has been attained in investigating various tests of physical efficiency. A number of observations have been published on pulse phenomena, in particular comparing the pulse rate for the two minutes following exercise with the pulse rate at rest, and it has been found that the ratio of the two is a good indication of physical fitness for relatively mild muscular exercise. In strenuous exercise, on the other hand, such as running a mile, the fittest men are found to be those who show the greatest percentage rise in the pulse rate on working and the greatest percentage fall on rest. On these results it is thought possible that a test may be devised to indicate the fitness of individuals for certain kinds of work. It may perhaps also be hoped that research of this sort may lead ultimately to the elaboration of some test for fatigue itself, the absence of which is one of the great difficulties of the study of industrial fatigue.

The present report mentions a number of other investigations, completed or in progress, to some of which attention has already been drawn in these columns, and shows that the Board is continuing its activities all along the varied line it has already laid down for itself. It concerns itself with general subjects, such as the optimum length of working spell, the possible relation of accidents to various circumstances with which their incidence may be connected, and occupational sickness and mortality; with industrial investigations, such as those in the textile industries, of some of which an account has appeared in ENGINEERING earlier in the year, and others in the boot and shoe, pottery, and latch and lock industries; and with researches such as those instanced above, and others including investigations into the effect of rest pauses and change of posture, atmospheric conditions, the relation of accuracy of movement to speed and continuity, and a variety of subjects bearing largely on vocational selection and guidance. Among those of general interest may be instanced an inquiry into the nature and causes of telegraphists' cramp among Post Office operators, and another into the factors of legibility of print and the optical properties of paper and ink with reference to eye strain, the latter undertaken with the co-operation of Mr. Legros, who was responsible for the technical work of the Treasury Committee, at whose instance the investigation was started.

Of the work indicated as in prospect, perhaps the most interesting to engineers is the announcement that the Board is now contemplating a "rather close inquiry into the question of design in the case of certain types of machine, in order to ascertain whether any principles can be evolved indicating the proper relationship of machine to operator." In various previous investigations it had been found that the needs or convenience of the operator did not appear to have been studied as much as was desirable, and though the Board would be unwilling to undertake the work involved in reconsidering the principles of design of machines, such as typewriters and motor-cars, where ease of working is already sought as a primary object, the report observes with justice that in many other machines —doubtless in particular machines intended for manufacturing uses—the manipulative side of design seems often to have been "overlooked in favour of the purely mechanical." The announcement is to be welcomed on two independent grounds. Undoubtedly the Board has put its finger on what often is a weak point of machine design, and a systematic survey of the subject could scarcely fail to yield results of great importance in the economy of labour and the saving of fatigue. What, however, is even more welcome is the implication that the inquiry will involve—as unquestionably it must, if it is to be undertaken with any prospect of success—the joint work of an engineer in planning and supervising the inquiry.

For it cannot be questioned by anyone who has followed the study of fatigue in this country in recent years that a capital reason for its relative sterility of results and for the absence of any close approach between those who have been engaged on the study and those who are concerned in the engineering industries, is that the work has been undertaken by men who, however able or even distinguished in the practice of their own science, have industrially been amateurs. Even relatively simple problems of applied science usually require, when they come to be investigated in the laboratory, various simplifying assumptions, and the use of the investigations for any practical purpose depends on the aptness with which these assumptions are made. But problems of the industrial use of human energy are not simple, and many of the conditions under which they appear in practice have technical complexities of their own, which up to now cannot be defined or, sometimes, even explained in scientific terms. They have to be put in by eye; and the fault of the investigations of fatigue that up to now have disappointed expectations is that they have been put in by inexperienced eyes.

A man who can be trusted safely to put in the corrections and adjustments necessary for any practical result in industrial investigations of fatigue, and to avoid the pitfalls into which scientific amateurs egregiously fall when they try to make these corrections for themselves, must possess many qualifications, of which none can be improvised. He must himself be a craftsman; a man of his hands, familiar with the ways of the materials and tools to be used and the methods of getting the best out of them. He must be, or have been, the associate of other craftsmen, familiar equally with their little ways, their likes and dislikes, the influences that operate on them, and the methods by which they seek to adjust matters to their own liking when they are disposed to dislike them as they are. He must know the technology of his industry, seeing that he will continually be meeting situations in which trifling variations in technical circumstances, often imperceptible to the amateur and seldom or never to be rated accurately by him, may exert a greater effect on the phenomenon under examination than the entire range of variation that is under inquiry. And finally he must be trained in the methods of experimental science, so that he may be able to view the work in which he is co-operating as part of a web of knowledge in which each fibre is woven into the net, and the fabric is torn if the connection is broken. These are, indeed, qualifications that can be found only in exceptional engineers, but nothing less than them will be sufficient for the exceptional work that the Board has undertaken. The suggested investigation into the ease of operation of machines is not among the most difficult engineering problems into which the Board's investigations must extend if they are to satisfy the terms of the reference under which it was constituted. The difficulties are, however, typical of those by which its other work in the same field is beset, and it will be a matter of congratulation both to the Board and the engineering industries if the co-operation that seems to be forecasted by the investigation into the relation of machine design to fatigue is in fact realised during the present year.

RECORDING AND INTEGRATING GAS CALORIMETER.

THE Gas Regulation Act of 1920 removed certain disabilities as to the quality of the gas from the gas undertakings, but obliged them to supply a gas of a previously declared calorific value. If at any period the actual value should sink by 6 per cent. below the declared standard for a period of more than two hours, or if in any quarter the average should not come up to the declared value, the gas company might have to refund amounts paid, and such repayments, Mr. C. Vernon Boys, F.R.S., stated at the Royal Institution last Friday, had actually been made in two cases. The new "Recording and Integrating Gas Calorimeter" which Mr. Boys exhibited on this occasion is the outcome of three years of hard study devoted by him to the development of an instrument that will safeguard the interests of both the gas makers and gas users. Recording instruments of exceptional accuracy and reliability are required. Some 50,000,000*l.* are annually being paid in the United Kingdom for gas, and an error of 1 per cent. in the calorific value would make a difference of 500,000*l.* Mere average correctness would not meet the case in view of the necessary restrictions as to fluctuations. Mr. Boys calls one of the mechanisms of his calorimeter the "thinking machine." There are other ingenious devices in his instrument, which appears to be able to run on for months practically without attendance, and the utility of the devices is by no means limited to calorimeters.

The calorimeter which we illustrate in the photographic view and diagrams, Figs. 1 to 7, on pages 560 and 561, is of the water-flow type, but Mr. Boys does not simply trust to the operation of natural laws to determine either gas flow or water flow. He "doles out" both water and gas positively at the correct rate, and effects the correction of the gas volume for temperature and pressure again by a positive operation. Celluloid is largely used as material to make parts light and transparent. The calorimeter (Fig. 1) stands about 6 ft. high on a base of 3½ ft. by 2 ft. The characteristic parts, the bucket, water box and wheel, calorimeter box, clock, &c., are all in the upper compartment. There are two tanks of 10 gallons capacity. In the upper tank the water level is kept constant, and the water, filtered through copper gauze, is circulated continuously, day and night, through the instrument; thus no water is wasted—the calorimeter water bill might amount to 20*l.* a year—except when water is drawn off for a test; but a little copper sulphate has to be added to the water to prevent organic growth. The circulation pump (shown at the bottom of Fig. 1) is driven by one of the hot-air engines, used for punka driving, &c., made by the Model Engineering Company, the flywheel is a fan which cools the water coil, and the 1½ in. cub. ft. of gas which the engine burns per hour is considered useful to keep the gas in the service-pipe alive. From the upper tank the water flows into a celluloid bucket, which tilts, is caught by a detent, drained into a water box, and released again every half-minute. The amount of water required to tilt the bucket is regulated by a stop in such a way that gas of the declared value would raise the temperature of the water by exactly 10 deg. C., the gas flowing at the rate of ½ cub. ft. per hour under standard conditions. The record made on the sheet would then be a straight line running down the middle of the sheet, and a deviation of 0·1 in. to the right (or left) would signify an excess (or deficiency) of 0·1 deg. C. or of 1 per cent. of the calorific value. Mr. Boys measures his gas in cubic feet, and his water in cubic centimetres, in order to facilitate calculations. The capacity of the bucket is adapted to the calorific value declared by the company concerned.

The water box mentioned consists of a front and a back box; each box comprises two compartments communicating through a small hole. The bucket water enters the front box, and, later, we shall see, into the calorimeter proper. While the bucket is being tilted, the water jet passes into the back box and from this over a small overshot wheel which, in turning, drives an escapement pendulum clock of one wheel, ticking half-seconds (the clock is to the right of the calorimeter box, but not visible in Fig. 1), and drives further through an intervening mechanism (the thinking machine), the axis of the gas meter, which is shown in longitudinal vertical section in Fig. 2, and which we will first describe. It is of the wet-meter type, but doles out the gas at the desired rate in spite of thermometer and barometer fluctuations; it would answer for hydrogen and carbon dioxide as well as for coal gas. The casing consists of a spun copper bowl *c* on the plane brass flange *b* of which rests a glass bell; vaseline is used to keep these and other joints watertight without stuffing boxes. Before entering at *e* the gas is sent through a Woulfe bottle to be saturated with water vapour; the pins *p* serve for adjusting the water level. The axle *a* of the drum *d*, which is made of celluloid, runs in a long sleeve;

the weight of the drum is largely carried by the buoyancy chamber *h*, from which the usual four partitions *r* radiate. The gas is admitted into the drum through *e* and *f* and the passages *i* (about ½ in. square), leaving again through the passages *o*.

The drum *d* is loose on the axle, but screws on to it. When both turn at the same rate, there is hence no endlong movement, but should the drum run faster (*e.g.*, because the clock and axis stop), it will screw along and close the gas valve at *f*. Should, on the other hand, the gas supply cease, the drum being no longer driven screws up to a stop on the axis, which, encountering too great a resistance in the absence of gas supply, stops the clock. The object of the "thinking machine" now is to gear the meter speed down in the ratio 6 : 1 (so that the axle makes one turn in three minutes), and, further, to make the gas volume corrections. The mechanism is a small ball-disc cylinder integrator (shown in vertical section in Fig. 3) as invented by James Thomson, coupled with an epicyclic reduction gear (shown in plan in Fig. 4) which reduces the motion of the disc in the ratio 3 : 2, and the motion of the cylinder in the ratio of 15 : 1, i.e., 10 times as much, the disc itself being geared down from the water wheel in the ratio 4 : 1. The motion of the cylinder C depends upon the position of the ball B (Hoffmann bronze, 1½ in. diameter), which is itself determined by an air bell H floating in a mercury and water seal in such a way that, with a change of gas volume of 10 per cent., B moves 1 in., which is the radius of the cylinder C. When the ball makes contact with the rotating disc D exactly at the centre of D, no rotary motion will be imparted to B and C; that position corresponds to the normal temperature and pressure condition. When the ball is displaced, endlong motion is communicated to the meter drum, and the valve *f* (Fig. 2) is closed or opened. The fork F which directs the ball B rolling in the groove formed by the inclined disc D and the cylinder C carries a pointer (not shown) moving over a volume scale, thus enabling the examiner to see whether the bell H is correctly placed in its bath. By means of a further epicyclic drive (not shown) which converts a rotation of one turn per minute into one turn per month this pointer movement is recorded. The wheels W, W, are gear wheels with skew teeth.

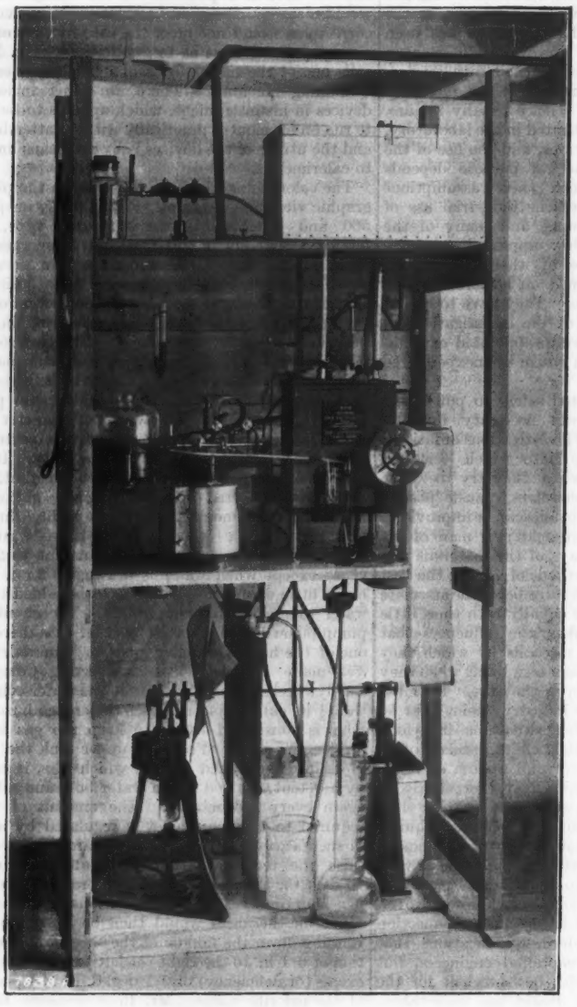


FIG. 1.

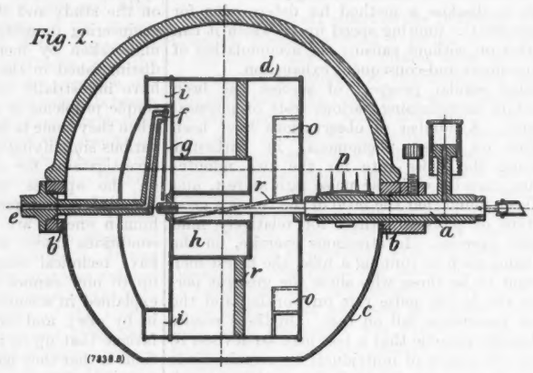


Fig. 2.

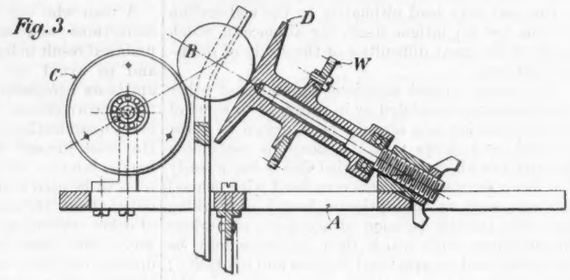


Fig. 3.

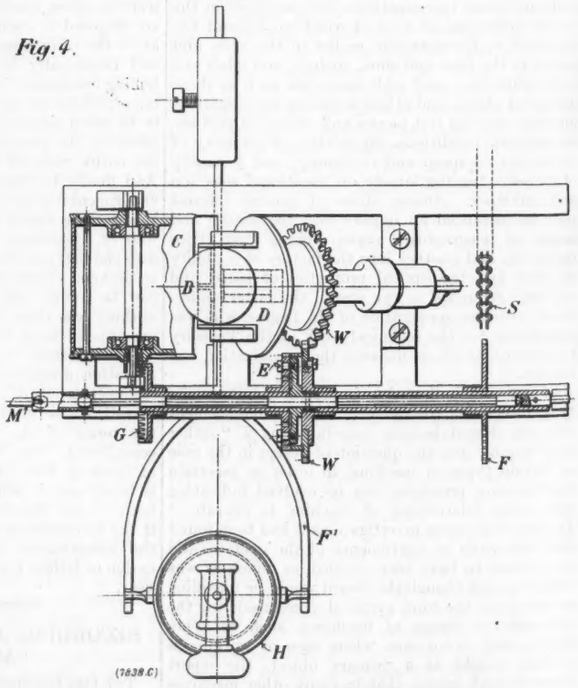


Fig. 4.

We now pass to the calorimeter proper and the "operative thermometers" which are shown in vertical cross-section in Fig. 5 and in plan in Fig. 6, Fig. 7 giving details. The water from the front water box flows through a wide pipe into the upper part of the cold chamber 2, Fig. 5, down to the base and into the annular lead trough 21 which is joined to the heat interchanger 7, a peculiarly-folded cylinder of lead foil, enclosing the gas burner (made of silica) 23. Over the top of the burner lies the silica dome 8, itself capped by the upper cover of the lead. The lead foil is closely folded radially into 15 zigzags around the central combustion space (from which the combustion products escape at 22, at the bottom), providing a set of extremely narrow up-cast water-ways on one side of the sheet, and of voluminous down-cast gas-ways on the other; only one longitudinal seam is needed for separating the two ways. How the soldering of the thin foil is effected will presently be explained. Over the outside of the lead cylinder fits the cylinder 3, made of nickel silver, of the hot-water chamber. The water heated by the gas rises through the narrow annular space between the two cylinders, passes over the lead cap, and enters the hot-water chamber underneath the hot thermometer 6.

The two operative thermometers, 5 and 6 (Figs. 5 and 6) are identical in construction and consist each of a brass cylinder 3 in. high, 2⅞ in. diameter, now provided with a corrugated top; originally both

top and bottom were corrugated, as in Fig. 5. The cylinders are filled with amyl alcohol. Both the thermometers are wholly immersed in the cold or hot water, and the hot thermometer is insulated by being jacketed with some of the hot water (discharged at 4 from 6); the copper sheet 9 forms the outer wall of this jacket. Heat loss by radiation is thus prevented. The thermometers being 3 in. long, and the expansion coefficient of amyl alcohol being about 0·001, a piston in the thermometer

Fig. 5.

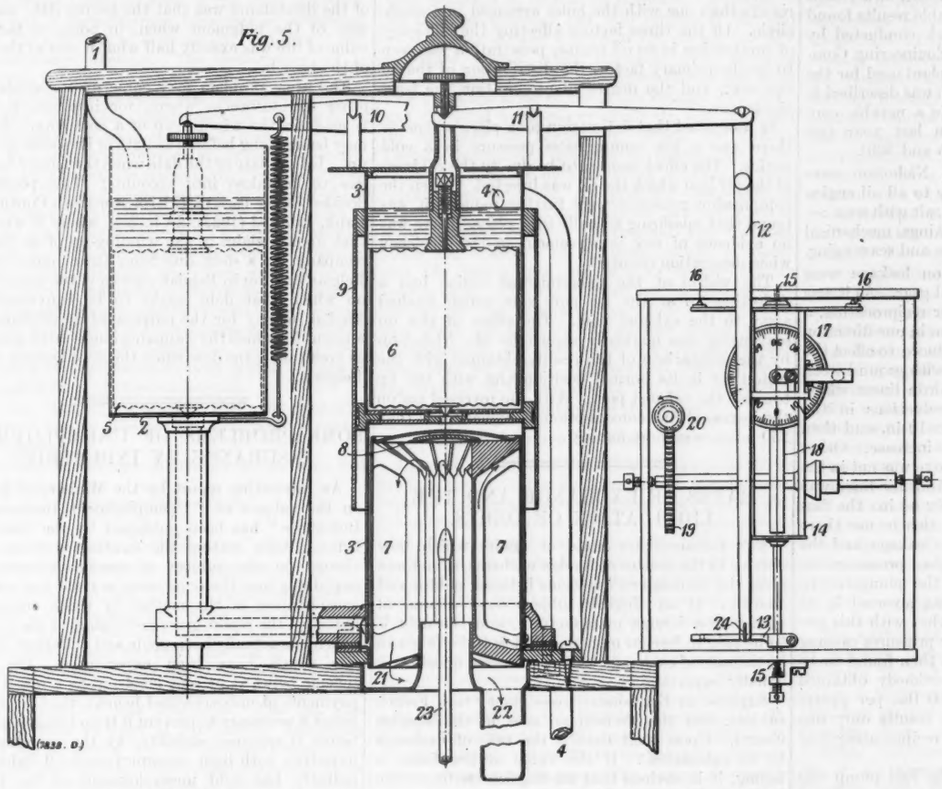
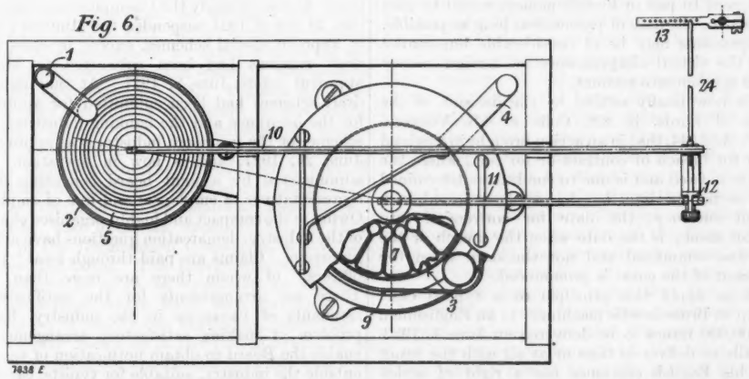


Fig. 6.



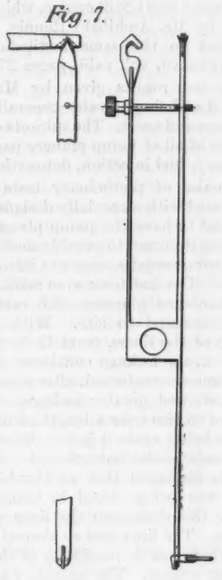
cylinder would move by 0·003 in. for every deg. C. change of temperature. The corrugated cover increases that expansion by nearly one-half; but even then an error in the thermometer position of 0·002 in. would mean a loss of about 500,000*l.* annually, on the gas bill above mentioned. The magnifying lever system and other means adopted to obtain distinct records are again novel: "the third dimension of space" has been called in, as Mr. Boys remarked.

On the top of the hot water chamber are mounted two pairs of pillars forming the fulcra of two parallel primary levers 10 and 11 (Figs. 5 and 6). From 11 hangs, by a knife-edge on the long arm of 11, a long bell crank lever 12 (shown in side elevation and part front view in Fig. 7), the other end of which presses up against the primary lever 10 (held down by a spring). The bell crank lever thus hangs in a plane at right angles to the plane in which the two primary levers move up and down. The result of this suspension is that, when the two primary levers rise or fall in unison, the bell-crank lever follows suit, moving through $2\frac{1}{3}$ times the range, but it does not cant; with any differential movement of the primary levers, however, the bell crank will cant. This latter movement is communicated by a link 24 to the short arm of the pen lever 13. The axis of lever 13 or lantern (it is a rectangular framing) is vertical; at 15 are the pivots of the lantern, and at 16 the upturned points on which the pen arm rests, fully balanced so as not to press against the paper. The pen is a fine silver tube, 9 in. long, carrying enough ink of a special kind for a year. The axis of the clock—the same as previously mentioned—carries a worm 20 engaging with a worm wheel 19 of 60 teeth on a cross shaft which rotates once every half minute.

The shaft turns at the one end the recording drum (not shown in the diagram), and at the other end, through another worm, an integrating drum 18 both rotating at the same rate, once a day. An integrating wheel 17 of the Amsler planimeter type, carried by the lantern and partly counterbalanced, rests lightly on the drum 18. When this drum, which is divided into 100 parts, integrates five divisions after having been set to zero on the last inspection, that will mean that the gas has been of its declared value over the whole period, except for five days, when it was 1 per cent. high, or for one day when it was 5 per cent. high.

The recording drum (Fig. 1) bears an endless paper belt which is weighted below, moving at the rate of $\frac{1}{2}$ in. per hour and sufficiently long for 14 days' records. Mr. Boys prefers plain unruled paper, the ordinary ruling not being trustworthy. He uses a perforated plate, as part of the calorimeter

Fig. 7.



mechanism, for making his own ruling and inks of different colour supplied from celluloid ink wells; the time scales are easily distinguishable from the other scales.

The non-recording spot-test calorimeter which Mr. Boys finally showed, is a smaller instrument of the same type, simplified by dispensing with the thinking machine and the integrating and recording drums, and by substituting ordinary mercury thermometers for the operative thermometers. The spot-test calorimeter will serve until the new calorimeter—not yet officially adopted—is established, and later on as well; steady conditions for a test can be obtained in it within 10 minutes, whilst it would take nearly an hour to take a test with the large calorimeter, and tests have frequently to be performed.

We mentioned the lead-soldering. The lead foil used in the interchanger has a thickness of only 0·035 in., and ordinary soldering would fuse the foil into lumps. To make these delicate seams, a cool flame is required. The actual soldering is effected by means of a very small arc of 200 volts between the lead and a carbon pencil, the pencil being moved at the rate of about a foot per minute. A jet of mixed gases carbon dioxide and hydrogen, is directed on the arc; the mixture ratio is adjusted until a reducing atmosphere is produced which will barely melt the lead. Coal gas would probably do as well as hydrogen.

Mr. Boys illustrated his discourse by the aid of his own model instrument and numerous models of characteristic parts—patents for which have been granted to Mr. Boys and the Board of Trade—and by the latest form of his integrating calorimeter, as manufactured by Messrs. John Griffin and Sons, to whom we are indebted for the drawings.

OIL ENGINE EXPERIMENTS.

Of the many problems confronting the designers of oil engines some will be solved through the gradual accumulation of experience in running, while many will be eliminated altogether, as a result of the experimental work conducted by the individual firms and the research associations. A paper on "Some Oil Engine Experiments" read by Mr. Andrew I. Nicholson before the Institution of Engineers and Shipbuilders in Scotland, at a recent meeting, contained some very valuable results found in the course of experimental work conducted by Messrs. Scott's Shipbuilding and Engineering Company, Limited, of Greenock. The plant used for the work was a Scott-Still engine, which was described in detail by Mr. Archibald Rennie, in a notable contribution to the same institution last year (see ENGINEERING, vol. cxiii, pages 275 and 309).

The test results given by Mr. Nicholson were selected as being of value generally to all oil engine designers and users. The subjects dealt with were:—leakage of oil at pump plunger packings, mechanical efficiency, fuel injection, detonation and scavenging.

A series of preliminary tests on leakage were performed with a specially designed gear. As it was essential to have the pump plunger reciprocating, a cam was designed to provide motion in one direction and a compressed spring was introduced to effect the return. The first tests were made with ground steel, case-hardened plungers with cast-iron liners which were reamered to size. With reductions in the length of the liners, from 12 in. to 10 in. and then to 7 in., the leakage continued to increase. Other experiments conducted, after a groove was cut in the liner, showed greater leakage. Another liner was ground to size over a length of only $4\frac{1}{2}$ in., the diameter being again $1\frac{7}{16}$ in. With this in use there were substantial reductions in the leakage, and the results indicated that at the higher pressures the liner was being closed in upon the plunger. To verify this deduction the liner was reversed in its casing. The liner was so shaped that with this setting there was no possibility of the pressures causing closing actions. The leakage was then found to be no less than eight times the previously obtained figures for an oil pressure of 2,000 lbs. per square inch. The stationary tests gave results only one half of those obtained with the reciprocating gear in use.

For the experimental engine the fuel pump was constructed on the basis of the arrangement found to give the smallest leakage, and the later tests with the actual engine were found to confirm the results obtained with the experimental gear. Further tests were made to determine the friction of the plunger in the liner or packing, by measuring the minimum compression of the spring required to keep the plunger on the cam. The friction was greater with the ground liner than with the reamered one and greater still when white metal packings, which made the leakage almost negligible, were introduced.

The determination of the frictional mean pressure for the Scott-Still engine was possible by two different methods, running the engine light on steam and by comparing the brake horse-power with the indicated value. A check method was also used; in this case the engine was run at full speed, every source of external power was cut off, and the retardation ascertained. As the moments of inertia of the moving parts were known it was possible to find the value of the engine friction. Mr. Nicholson gave curves of the mechanical efficiency plotted against the brake horse-power for running at constant speed and with the revolutions varying as the cube of the power, approximately in accordance with the variation of revolutions and power on a ship. They showed results rising to 89 per cent. at 350 b.h.p., and still continuing to increase on overload. The low mechanical efficiency on small loads when the engine was controlled to run at constant speed led Mr. Nicholson to suggest that electrical engineers might consider if electric generators could not be controlled in some other way.

The oil was introduced by solid injection and not blown in by air. Experiments were conducted with vortex or whirling sprayers, with an ejector type and with small-hole sprayers. Investigation in this field presented difficulties because it was almost impossible to change one variable at a time, but the results clearly indicated that atomisation must not be regarded as the principal consideration in the obtaining of efficient combustion. In some tests with sprayers provided with eight holes of diameters between 20 mils. and 24 mils. it was found that the largest jets gave the best results. When the number of holes was varied it was observed that whenever the jets began to touch one another the combustion efficiency fell away. A sprayer cup with the holes distributed in two circles invariably gave worse results than one with the holes arranged in a single circle. Of the three factors affecting the efficiency of combustion in an oil engine, penetration was seen to be the primary factor, the distribution of the oil the next, and the degree of atomisation the least significant.

It was noted that detonation took place whenever there was a low compression pressure in a cold engine. The effect seemed to be due to the coldness of the air into which the oil was injected. When the compression pressures were further reduced it was found that missfiring actually took place. There was no evidence of any improvement in the efficiency when detonation occurred.

The piston of the experimental engine had a deflecting lip at the air port side which washed away to the exhaust port. The effect of this on scavenging was markedly shown by Mr. Nicholson by the comparison of the results obtained with the piston set in its normal position and with the lip towards the exhaust port. With the reversed piston the increased fuel consumption at higher loads than 250 b.h.p. was most marked.

RATES OF EXCHANGE AND THE LIQUIDATION OF DEBTS.

The extraordinary state of affairs which now obtains in the matter of foreign exchange sometimes gives rise to complex questions between debtor and creditor. If an English subject owes a sum of money to a foreign manufacturer, and the debt is to be paid in foreign money—what is to be taken to be the rate of exchange? The converse question is equally important.

Suppose an Englishman owes money to a French subject, and the Frenchman sues in the English Courts. Upon what date is the rate of exchange to be calculated? If the value of the franc is falling, it is obvious that an English creditor, who had agreed to pay in French money, would be glad to postpone the date of payment as long as possible. The questions may be of considerable importance when the virtual disappearance of foreign money values is taken into account.

It is now finally settled by the decision of the House of Lords, in S.S. Celia *v.* S.S. Volturno (1921), A.C. 544, that in an action brought in England either for breach of contract or for tort, where the damage is fixed and is due to conditions determined at a particular date, but has to be assessed in a foreign currency, the date for conversion into English money is the date when the breach or the tort was committed and not the date when the judgment of the court is pronounced.

Let us apply this principle to a typical case. A man in Brussels sells machinery to an Englishman for 100,000 francs to be delivered on June 1, 1923. He fails to deliver in time or at all with the result that his English customer has a right of action against him, the measure of damages being the difference between the contract price of the machinery and the price which the customer has to pay on or after June 1 to replace that which the Belgian has undertaken to deliver. Assume, for the sake of argument, that this difference amounts to 20,000 francs, for which the English creditor has to bring suit. Is he entitled to 20,000 francs as at the rate of exchange ruling on June 1, 1923, or as at the rate ruling on the date when he secures his judgment? The decision of the House of Lords makes it plain that the rate of exchange which governs is the rate current at the date of the breach.

In the earlier case of Di Ferdinando *v.* Simon, Smits and Co. (1920), 3. K.B. 409, the defendants contracted to carry goods for the plantiff from this country to Italy and deliver them there on February 10, 1919, but in breach of contract they failed to do so and converted the goods to their own use. In an action by the plaintiff the court fixed the damages as the value of the goods in Italy on February 10, namely, 190 lire per 100 lb. It was held that in arriving at the proper equivalent in British currency for the purpose of assessing these damages, the rate of exchange prevailing between the two countries on February 10, 1919, when the breach was committed and not that prevailing at the date of the judgment should be adopted. The suggestion put forward on the part of the defendants was that the proper date was the date of the judgment when, in point of fact the value of lire was exactly half what it was at the date of the breach.

The same problem may come up for solution in other circumstances where, for instance, a claim is made in the winding-up of a company. A debt may be due long before the date of the order to wind up. Is that date or the date when the money became due to be taken into account? This point was decided in the case of British American Continental Bank, Limited (1922), 2 Ch. 589, where it was held that upon a claim in the winding-up of an English company for a debt due from that company to a Belgian creditor in Belgian currency, the correct date on which that debt ought to be converted into English money for the purpose of ascertaining the amount for which the claimants ought to be admitted as creditors is the date when the debt became due in Belgium.

SOME PROBLEMS OF UNEMPLOYMENT INSURANCE BY INDUSTRIES.

An interesting report by the Ministry of Labour on the subject of "Unemployment Insurance by Industries" has been published by the Stationery Office. After stating the existing statutory provisions on the subject of special schemes, and explaining how the depression in trade has retarded consideration of the matter by those engaged in industry, the report gives particulars of the progress which has actually been made and of various difficulties which have been experienced. The State scheme being at present insolvent as a result of the payments of uncovenanted benefit, the Government found it necessary to prevent it from being weakened, before it regained stability, by the withdrawal of industries with light unemployment—if indeed any industry has light unemployment at the present time—and accordingly the Unemployment Insurance (No. 2) Act of 1921 suspended the Minister's power to approve special schemes, except in cases where draft schemes had been submitted to him for approval before June 8, 1921. At that date two draft schemes had been submitted for approval—for the insurance and the banking industries. The scheme for the insurance industry was approved on June 24, 1921, and is now in operation. It is administered by a joint board consisting of five representatives of employers and five of employees. Owing to the compact and highly-organised character of the industry, demarcation questions have not been numerous. Claims are paid through local "paying officers," of whom there are more than 2,000. There are arrangements for the notification to claimants of vacancies in the industry, but the problem of making satisfactory arrangements to enable the Board to obtain notification of vacancies outside the industry, suitable for typists, caretakers and other persons on its fringe, has apparently not yet been solved, and is still under consideration. The arrangements with regard to "transfers" between the State scheme and the special scheme are still tentative.

A preliminary difficulty has, so far, prevented the scheme for the banking industry from being approved. The Minister of Labour is not satisfied that the Banking (Employers and Employees) Unemployment Association, which submitted the scheme, represents a majority of the employees in the industry.

Prior to the embargo placed on contracting-out by the No. 2 Act of 1921, a few industries drew up draft schemes tentatively for discussion, including the woollen textile, the hosiery, the boot and shoe, the printing and the wire-making industries. Demarcation difficulties which arose sharply in

connection with the wire-making scheme had not been solved when consideration of the matter was adjourned on account of the embargo. The Joint Industrial Council for the Hosiery Trade attempted to avoid the demarcation difficulty by limiting the application of its projected scheme to undertakings represented on the Industrial Council; but the definition by reference to a constitution of a voluntary body which might vary from time to time was clearly too indefinite for insertion in a statutory order.

The report mentions some of the main difficulties in the way of unemployment insurance by industries:

(1) The difficulty of defining an "industry" with the necessary precision. The demarcation of an industry, it states, is possible only by means of a large number of more or less arbitrary decisions assigning particular establishments or parts of establishments to some particular sphere.

(2) Few industries provide employment throughout the year for all the workers they need at certain seasons. In many industries a large number of the workers seek employment elsewhere during part of the year, and in most there is a "fringe" of workers who are not regularly employed in those industries, *e.g.*, unskilled labourers who may work in half a dozen different industries in the course of a year.

(3) Special schemes must in general be put forward with the approval of a Joint Industrial Council or a joint association of employers and employed sufficiently representative to carry with it the assent of the great body of those concerned.

(4) The Ministry consider that the financial hazards of special schemes have probably operated as a deterrent.

This list of inherent difficulties is, we fear, not exhaustive.

NOTES.

Photometric Definitions.

In February of last year a provisional list of definitions of photometric terms and units was published by the National Illumination Committee of Great Britain and has been adopted by the three constituent societies—the Illuminating Engineering Society, the Institution of Electrical Engineers and the Institution of Gas Engineers. The list also forms the basis of a set of photometric definitions shortly to be issued by the British Engineering Standards Association. The preliminary definitions agree generally with the decisions arrived at by the International Commission on Illumination, which was held in Paris in 1921, but go somewhat further and are, in some respects, at variance from the set of definitions approved by the American Engineering Standards Committee last July. Possible modification of the preliminary definitions is now being considered with a view to minimising the points or difference from the American definitions. An English translation of the official French text of the definitions which were adopted in Paris in 1921 has been prepared by Dr. Mailloux and Mr. K. Edgcumbe, and forms an appendix to the 1922 Report of the Illumination Committee, which has just been published. The Report announces that a sub-committee is to be appointed to consider recommendations which have been published on the question of automobile headlights, particularly those recently drawn up in the United States by a Committee under the chairmanship of Dr. Clayton Sharp. An International Committee to inquire into this question was appointed at the Paris Meeting in 1921, and the work of the new sub-committee will be directed towards common International agreement. The Secretary of the National Committee is Mr. H. Buckley, of the National Physical Laboratory.

The Development of the Steam Turbine.

At the Royal Society of Arts on Monday last, Mr. Stanley S. Cook, B.A., delivered the first of his Howard Lectures on "The Development of the Steam Turbine." He first of all demonstrated the great advantage possessed by the steam turbine over the reciprocating engine, in the more complete utilisation of the expansive properties of the steam. The simple pressure-volume diagrams for the work done by the steam in the cylinders of a quadruple expansion engine drawn on top of that for a steam turbine, as well as the figures obtained for the two cycles when plotted as the product of the pressures and volumes against the logarithm of the absolute pressure, were used to emphasise the distinction. The lecturer then traced the development of the direct-coupled steam turbine and referred to the fact that even with the low efficiency of turbine and propeller due to the unsuitability of the speeds of running, the superiority of the steam turbine over the reciprocating engine was so marked that turbines were installed in increasing numbers. A graph of the total horse-power put into service at the end of each year showed a gradual rise during the probationary period, when engineers were studying the potentialities of the new prime mover, but after four years the slope of the graph became very steep and the total horse-power of all the sets built ran up suddenly to 15,000,000. When Sir Charles Parsons introduced gearing to obtain the most suitable speeds for high efficiency working of both turbine and propeller, the progress curve showed exactly the same characteristics as that for the direct-coupled system. A gradual rise for four years was followed by a sharp change of slope, and the two graphs had almost exactly similar inclinations. Mr. Cook described the changes of lay-out of the separate components of a ship's propulsion plant at all the various stages in the developments, and referred to the gradual increase from year to year of the constant obtained from the product of the squares of the blade diameters and revolutions per minute of the turbines.

The Johnson Penstock Valve.

In view of the large number of applications in modern hydro-electric installations of the Johnson type of penstock valve, a recent decision in the United States' Courts is of interest. The introduction of the Johnson type of valve marked a great advance in the control of large hydro-electric units, and Mr. R. D. Johnson was awarded the Elliott-Cresson medal of the Franklin Institute, in recognition of the value of his invention. We illustrated large 14-ft. valves of this type in connection with the description of the 55,000 h.p. turbines of the Queenston-Chippawa power station in Ontario.* These valves were built by the William Cramp and Sons Ship and Engine Building Company (I. P. Morris Department), who now have under construction similar valves, 21 ft. in diam., for the new power station at Niagara. The Cramp Company some time ago acquired the commercial rights for this valve for the United States and, we believe, for Canada. Previously they had been manufactured by the Wellman Seaver Morgan Company under royalty. A valve was subsequently placed on the market by the latter firm which has now been declared by the United States District Court for Northern Ohio, sitting at Cleveland, to be an infringement of the Johnson patent and consequently of the rights held by the Cramp Company. In giving his decision the judge stated that the Johnson invention was basic, and the plea of anticipation based on the prior invention of the Ensign valve failed, nor could that invention be considered as limiting the construction of the Johnson patent claims. The judgment states that the Johnson valve showed such differences compared with anything previously done that the question of date of prior patents was immaterial, the main feature of the Johnson patent being the manner in which areas subjected to high and low pressure were created on the two sides of the valve to effect its movement. The stream line form adopted was also declared to be novel.

The Improvement of the Locomotive.

We discussed recently in these columns the prospects of the use of the internal-combustion engine for locomotive work, and pointed out that in its present form the adaptability of this type of engine to such service left much to be desired. The subject, as we then said, has its attractions, and on a number of occasions recently both here and in the United States it has been referred to, with the evident wish that the prospects of such a machine were brighter. The ground has been traversed too often for us to need to reiterate the unfortunate features of the internal-combustion engine for the conditions which have to be met in railway work, but the case was put on a less usual footing in a paper recently read before the North-East Coast Institution of Engineers and Shipbuilders. In this paper, the author, Mr. T. Grimes, of Messrs. Hawthorn, Leslie and Co., Limited, pointed out that among steam engines, while that for the locomotive gains in simplicity and ease of control, it cannot compare with central station practice with regard to economy, on account of the difficulties preventing the introduction of refinements, and of matters arising out of the variable loading under which the machine works. So far, Mr. Grimes showed, attempts have been mainly directed towards adapting a refined and economical internal-combustion engine to locomotive practice, and he suggested that if the question were attacked from another side more might materialise from the effort expended. Supposing, as we do with the steam engine, that we are willing to accept something less than stationary practice gives, could a simplified and workable internal-combustion engine be produced? The suggestion certainly would appear to have possibilities, though it is difficult for the moment to see a clear line of advance. It is agreed probably that the present stationary type of internal-combustion engine is impracticable for incorporation in a locomotive. Mr. Grimes suggests that, by sacrificing a part of the improved thermal efficiency of this class of motor, we might arrive at a design which would partake of the characteristics of the steam engine with a still attractive promise of economy. For the rest, Mr. Grime's paper is an argument that the steam locomotive as we have it to-day, comparatively cheap, remarkably flexible, and self-contained, is a unit which is hard to beat, and that unless something comes along its equal in convenience, and greatly its superior in economy, which is not yet in sight, steam operation will persist.

Compression of Powders.

The authors of three papers on the compression of powders, brought before the Faraday Society, on April 23, had the satisfaction of finding themselves in agreement as to the conclusions at which they had arrived by different methods. Mr. J. H. Shaxby, M.A., director of the Viviamu Jones Physical Laboratory, University of Cardiff, and Mr. J. C. Evans, dealt with the "Variation of Pressure with Depth in Columns of Powders." In introducing his paper, Mr. Shaxby referred to an experiment shown by Major C. E. S. Phillips in 1910. A vertical tube was closed at the bottom by a piece of cigarette paper, held in place by a rubber strap; the tube was filled with sand, lifted up and then heavily loaded at the top, and yet the tissue paper remained unbroken—because the load was largely supported by the tube, and the paper had merely to bear the weight of a very shallow layer of the sand. Mathematically, Professor Selby had pointed out, the problem might be investigated on the assumption that the powder behaved to a certain extent like a liquid with a definite coefficient of friction with the wall of the containing tube. Mr. Shaxby found formulæ which experiments with sand, emery powder and lead shot, tended to confirm, though the further assumption made is by no means certain, as he was aware that the horizontal pressure at any depth be proportional to the vertical pressure. The pressure increases in an exponential ratio with the depth. The method of filling and density of packing are of influence in such experiments, and the thrust on the floor of a deep bin may vary enormously with various methods of filling; the flow-lines of the discharge of a powder through a hole in the bottom of a cylinder were very curious. The paper by Dr. E. E. Walker, of Cambridge, on the "Distribution of Density in Columns of Compressed Powders," led to the same main conclusion. The pressure that a plunger exerts on a powder is greatest immediately beneath the plunger and falls off with the depth of the column. This holds anyhow for dry regular powders, but not for damp sand and clay and materials which would react with one another. In his second paper on the "Compressibility of Powders," Dr. Walker described experiments made by forcing a steel

* See ENGINEERING, vol. cxiv, p. 34.

plunger into a steel cylinder charged with the powder, either by the static load of a Fairbairn machine (loaded to 4 tons and more) or by dropping weights on the plunger. Plotting the volume ratio (*i.e.*, the ratio of the apparent volume of the powder to the theoretical volume of the particles) against the resistance to the compression, he finds that static loads and impact loads give almost, but not quite, the same type of curves. The two curves are parallel to one another in the case of lead shot and ammonium nitrate; they diverge slightly as the compression increases in the case of sodium chloride, or they converge (calcium carbonate). The general compression would therefore be always of the same nature; but the particles may first disintegrate and then cement together again and harden on further compression, and hence the different types. The impact always produces relatively greater compression than the static load, as one would expect; but in this respect also the types differ quantitatively.

METAL PRICE DIAGRAMS.

NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

EXHIBITION AT BUFFALO, NEW YORK.—An "Iron and Steel Exposition" of power, mechanical and electrical engineering, is announced to open on Monday, September 24, at the Auditorium, Buffalo, New York. Mechanical, electrical and power plant apparatus will be displayed, in order to show the development of all these arts in the past year.

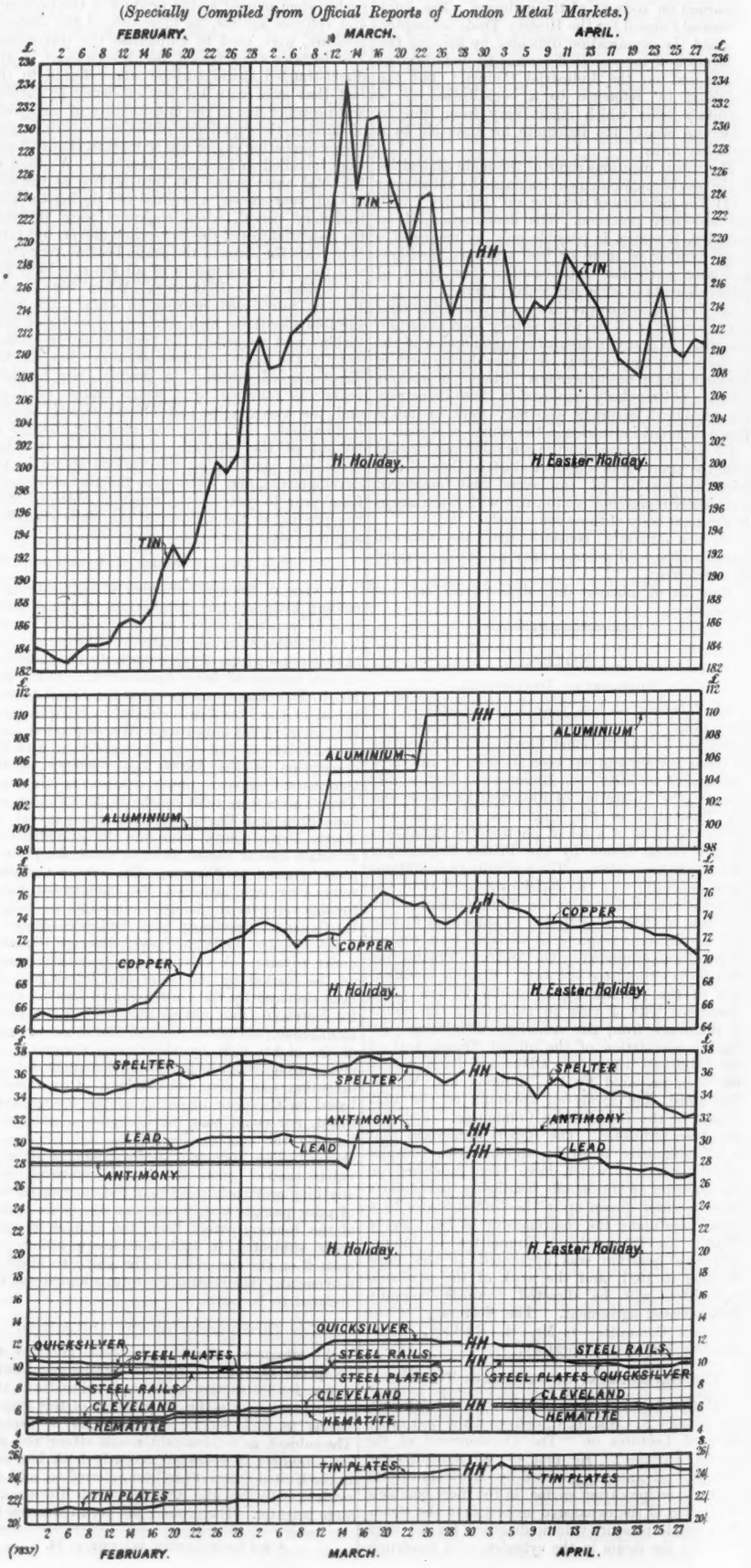
THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—The West Midland District meeting of this Institution is to be held on Saturday, May 12, at 2.30 p.m., in the Council offices, Queen's-road, Nuneaton, when a paper, "Notes on New Works of Water Supply," will be presented by Mr. R. C. Moon, borough surveyor. Visits are to take place to various places of interest. Applications are to be sent to Mr. A. R. Gray, City Engineer's Office, Council House, Birmingham.

INSTITUTION OF WATER ENGINEERS.—The twenty-eighth summer general meeting of the Institution of Water Engineers will be held at Winchester on May 30 and 31 and June 1. On May 30 members will be welcomed by the Mayor in the Council Chamber; the president-elect, Mr. H. C. Head, M.Inst.C.E., will be installed in his office and will deliver an address. Papers will be read and discussed. Wednesday afternoon is to be devoted to visits, while in the evening a *conversazione* will be held. On Thursday morning the meeting will be resumed for the reading and discussion of papers, the afternoon being again occupied with visits. In the evening the annual dinner will be held. On Friday a visit will be paid to Bournemouth, Lougham, Alderney and Beaulieu.

THE LATE MR. JOHN WILLIAMSON.—The pioneer of the application of the steam turbine to merchant ship propulsion died at Nice on Friday, April 27. When the commercial shipping community was very sceptical about the possibilities of efficient and reliable propulsion by steam turbines, Mr. Williamson approached Sir Charles Parsons and Messrs. William Denny and Brothers with proposals for the construction of a turbine steamer for service on the Clyde. They entered into his scheme wholeheartedly, and as a result the steamer, the King Edward, was launched in May, 1901. Ever since it was put into commission, the vessel has been a conspicuous success, and confidence in the reliability of the new prime mover was thus established. By his foresight the foundations were laid for the great development of the steam turbine in the propulsion of merchant ships.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



PORTABLE CONCRETE MIXER.

CONSTRUCTED BY MESSRS. DRUMMOND BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

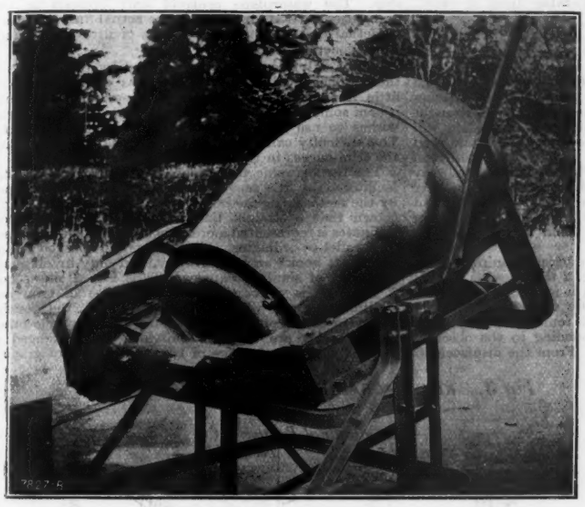


FIG. 1.

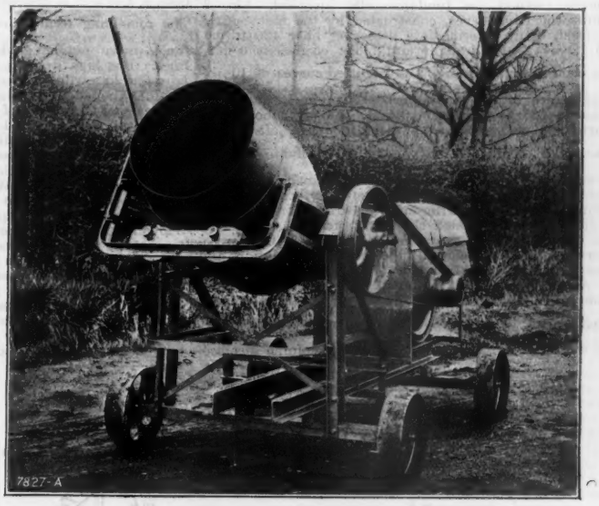


FIG. 2.

IT is generally recognised that concrete mixing with large units, having loading gears and conveyors, can be carried out with great economy and time saving. There are other fields of service, however, where the requirements are smaller and where the use of such plant is not warranted. For such work smaller outfits can be used with considerable profit. A plant of this character, made by Messrs. Drummond Brothers, Limited, of Guildford, is shown in the accompanying illustrations. The engine used for driving the concrete mixer is the standard 3-h.p. Willing Worker paraffin engine manufactured by the firm which was described recently in ENGINEERING (see vol. cxiv, page 707).

The mixing operations are performed in a steel barrel which receives its drive at the base. From the main pulley the power is transmitted through a dog-clutch which is actuated by a small hand lever and a spiral cam motion. A link belt chain and sprockets carry the drive to a bevel pinion, in the casing at the foot of the barrel, which drives a bevel wheel which is rigidly connected to the concrete container. The whole of this gear is effectively protected from dirt, concrete and water by covers. These are shown in the photograph, Fig. 1, taken from behind the barrel. As the bevel wheel revolves with the barrel and its cover is stationary there must be a space left, but it is so arranged that no falling matter can get to the gears, by recessing the bottom of the barrel and making the edge extend over the gear cover. With this efficient protection from the possibilities of abrasive material getting into the gear the working life of the machine must be greatly extended.

The barrel is reinforced by a steel ring which runs on rollers. As there is always a possibility of slight eccentricity and lack of alignment with any container, subjected to the harsh treatment which a concrete mixer must withstand, the rollers are not held in fixed positions, but are mounted on a travelling carriage (see Fig. 2), which is free to take up instantly any position required. The carriage itself is mounted on rollers which run on the front part of the steel frame.

The cradle on which the barrel is mounted is made up of rolled steel sections and is provided with a hand lever for tipping. The container has a working capacity of one-seventh of a cubic yard. As each batch can be mixed in from 1 minute to 3 minutes, according to the nature of the materials used, the total output of the machine is from 3 cub. yards to 8 cub. yards per hour. All the moving parts are lubricated by the use of screwdown grease cups.

The mixer unit may be removed from the trolley and thus leave the engine available for pump driving or other duties. A suitable support for such plant may be obtained on the long steel bearers, which may be drilled to accommodate the bolts. As a type of fly-wheel can be supplied which has provision for bolting to various sizes of pulleys the speed requirements of different pieces of plant can be met.

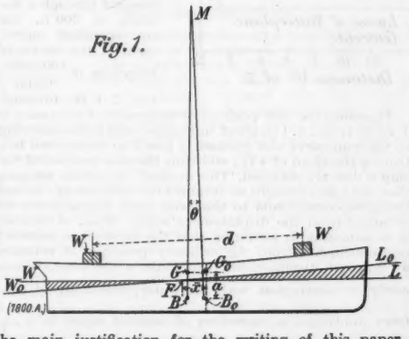
GRAPHICAL TRIM CALCULATION AND A TRIM NOMOGRAM.*

By E. V. TELFER, M.Sc.

THIS paper contains the results of part of the work upon which the author has been engaged during his tenure of the research scholarship awarded by the Commissioners of the 1851 Exhibition, to which he had the honour of being appointed by the Council of this Institution in October, 1920.

1. The aim of this paper is to develop that graphical method of trim calculation known as Long's trim-curves. It is shown that this method is merely a more convenient presentation of the metacentric method. The geometry of trim-curves is examined, as is also their usual presentation and practical manipulation. Finally, these curves are presented in the form of a trim nomogram, whose practical simplicity and utility is such as to form

Fig. 1.



the main justification for the writing of this paper. Nomograms or alignment charts, as they are sometimes called, are not widely known in applied naval architecture, but incidentally are closely related to the focal diagram sometimes used for the fairing of curves of experimental results. The science of nomography owes its inception to Professor Maurice d'Ocagne, who as far back as 1884 published a most comprehensive treatise on the subject. In this work and in succeeding publications the complete theory of the subject has been developed, and many practical applications are now in existence. It is of interest to state that probably the first application to a naval architectural problem is also due to M. d'Ocagne, who at the instigation of M. Bertin, expressed in nomographic form the complicated mathematical relationship involved in "The Stopping and Starting of Ships."† Naval architecture offers many useful applications for the principles of nomography, and much has yet to be done ere the possibilities of the subject are exhausted.

2. The trim of a vessel can be considered either absolutely or relatively. In the former case, for a given weight and position of centre of gravity, the distribution of buoyancy producing equilibrium can be obtained by manipulation of a frame integral (or Bonjean curve) profile. In the latter case the zero trim position satisfying the condition of requisite displacement is used as a standard, and only the redistribution of buoyancy necessary to produce rotational equilibrium need be investigated. These two methods applied over the available range of a vessel's displacement (or mean draught) enable the complete trim history of the vessel to be obtained. In the case of the former, for each mean draught, this history or information consists of a curve, giving for each position of centre of gravity the necessary trim to produce equilibrium. This method of presentation was developed by the late Mr. A. E. Long in a paper given before the North-East Coast Institution in 1906. In the case of the latter method the information is usually presented by specifying the moment to change 1 in., the tons per inch, and the position of the waterplane centroid at each draught. This is commonly known, of course, as the metacentric method, but in contradistinction to the absolute method, it may be also conveniently termed the differential method.

From the point of view of ease of manipulation Mr. Long's trim-curves, as they are called, are more convenient in practice than the metacentric method as ordinarily presented. Mr. Long in his paper did not show the relation which exists between his absolute presentation and the differential presentation. It was apparently assumed that the differential method was not sufficiently accurate for the larger trims met with in practice, and thus its possible transformation to the trim-curve presentation was not investigated. When, however, it is recalled that in the case of transverse stability the metacentric method is used without question up to angles of 5 deg. or so, it is not unreasonable to assume that it can also be safely applied to this extent in trim problems. An angle of 5 deg. corresponds to a trim of 35 ft. in a vessel 400 ft. long. As a trim of 10 ft. would be considered excessive in a vessel of this size, there should be no question of the accuracy of the metacentric method. As, further, one property of a trim-line pointed out by Mr. Long, viz., that these are always straight or very nearly so, can be shown to be a complete verification of the validity of the differential method, it will be profitable to examine how the ease of calculation of the differential method can be combined with the ease of manipulation of the trim-curve method.

3. In Fig. 1 a vessel originally floating at the water-line $W_0 L_0$ is rotated, by movement of a weight on board, through an angle $\theta = \frac{t}{L}$, t being the change of trim in feet and L the length of the vessel also in feet. The alteration in the position of the weight produces a change in the position of the centre of gravity equal to $G_0 G$. For equilibrium the horizontal separation of B and G must be zero. From the ordinary metacentric theory, if R is the longitudinal metacentric radius and a the vertical separation of B and G, then $B_0 B = R \cdot \theta = R \frac{t}{L}$; and $G_0 G = (R - a) \cdot \theta$. As a is invariably small compared with R, $G_0 G$ may also be taken as equal to $R \cdot \theta$ and hence to $B_0 B$. Thus we may write :—

$$G_0 G = B_0 B = R \theta = \frac{R t}{L} = x$$

From the relation $\frac{R t}{L} = x$ we have :—

$$t = \frac{L}{R} \cdot x \quad . \quad . \quad . \quad (1)$$

This equation is of fundamental importance in the

* Paper read at the Spring Meetings of the Institution of Naval Architects, March 23, 1923.

† *Bulletin Association Tech. Maritime*, 1911.

geometry of trim-lines. A trim-line, as defined by Mr. Long, has for its abscissa the quantity x above defined, and for ordinate value t, the resulting trim. As trim-lines were found in practice to be always straight, it follows from equation (1) that their slope is given by the quantity $\frac{L}{R}$. Thus the trim-curve method and the metacentric method are fundamentally identical. Fig. 2 shows the trim-curves, constructed by the metacentric method, of an intermediate passenger liner 420 ft. by 55 ft. by 24 ft. draught and block coefficient 0·668. At each draught in Fig. 2 are plotted curves of $10 \cdot \frac{L}{R}$ and centre of buoyancy in the even keel conditions, relative to the 'midship station. At and above any particular water-line, at a distance 10 ft. aft of the particular centre of buoyancy, an ordinate $10 \cdot \frac{L}{R}$ is erected. The tip of this ordinate is joined to the even keel position of the centre of buoyancy, and thus the trim-line obtained. Trim-lines are drawn for each main water-line, and through the 2-ft., 4-ft., &c., trim-point on each trim-line cross-curves are drawn. These cross-curves somewhat facilitate subsequent interpolation, and may be conveniently known as "iso-trims."

At this point it will perhaps be interesting to consider the geometry of the trim-lines and iso-trims. As is well known, $R = \frac{I}{\nabla}$, where I is the longitudinal moment of inertia of the waterplane, and ∇ the volume displacement. Expressed in terms of the fullness and principal dimensions of the ship this equality becomes :—

$$R = \frac{I}{\nabla} = \frac{f(a) \cdot B \cdot L^3}{\delta \cdot L \cdot B \cdot T} = \frac{f(a)}{\delta} \cdot \frac{L^2}{T} \quad . \quad (2)$$

in this expression :—

$f(a)$ is the waterplane inertia coefficient,
a is the waterplane area coefficient,
δ the block coefficient,
B the vessel's beam,
T the draught.

Substituting this expression for R in (1) we have :—

$$t = \frac{\delta}{f(a)} \cdot \frac{T}{L} \cdot x \quad . \quad . \quad . \quad (3)$$

If the waterplanes are assumed to be parabolic, $f(a)$ can easily be shown to equal $\frac{a}{12\,(3 - 2\,a)}$, and thus (3) could be written as :—

$$t = \frac{12\,(3 - 2\,a) \cdot \delta}{a} \cdot \frac{T}{L} \cdot x \quad . \quad . \quad (3\,a)$$

For a box-shaped vessel, $a = 1$, $\delta = 1$, this expression reduces to :—

$$t = 12 \cdot \frac{T}{L} \cdot x$$

For a triangular prism, $a = 1$, $\delta = 0{\cdot}50$, we have :—

$$t = 6 \cdot \frac{T}{L} \cdot x$$

For a solid with constant diamond-shaped waterplanes $a = 0{\cdot}50$, $\delta = 0{\cdot}50$, we have :—

$$t = 24 \cdot \frac{T}{L} \cdot x$$

These geometric solids can be safely taken as covering a much wider range than ordinary ship forms. From data recently published by Professor Scribanti* the value of the numerical coefficient ranges from 10·5 at a block coefficient of 0·35 to 14·28 at a block coefficient of 0·60, from which it decreases again to 12 at a block coefficient of unity. The practical range of the coefficient can thus be safely taken to lie between 10 and 15. This coefficient represents the influence of form and fullness on the slope of the trim-line; and as form comprises a knowledge of both a and δ it is difficult to generalise upon its effect. The remaining term in expression (3), *i.e.*, $\frac{T}{L}$, gives a much more potent guide to the behaviour of trim-lines. For high draught-length ratios the slope of the trim-line line will be great, and for low ratios it will be small. The effect of this ratio is the predominating influence on the nature of trim-lines. When the draught length ratio is increased indefinitely the trim-line will tend to become perpendicular to the water-plane, and when it is decreased indefinitely the trim-line will tend to lie along the waterplane. This tendency is clearly demonstrated by the nature of the iso-trims of ordinary vessels. From Fig. 2 it is seen that the upper trend of the iso-trims is asymptotic to the even-keel centre of buoyancy locus, and the lower trend is approximately asymptotic to the keel line.

4. We can now pass on to the practical manipulation of the trim-curves. Suppose in Fig. 2 the vessel is floating at a mean draught of 22 ft., and it is found that at this draught the vessel trims 2 ft. by the stern. Drawing in the trim-line at this draught it is found that the position of the centre of gravity corresponding to the observed trim is 4·2 ft. aft of 'midships. From the displacement scale it is found that the displacement corresponding to this mean draught is 9,500 tons. If now a weight of 100 tons is moved forward through a distance of 200 ft. the corresponding movement of the centre of buoyancy is $\frac{100 \times 200}{9{,}500}$, *i.e.*, 2·1 ft. forward.

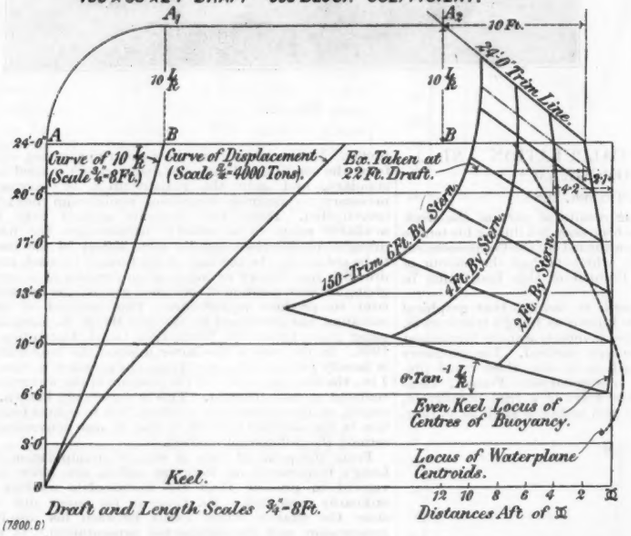
Therefore the new position of the centre of buoyancy is 4·2 − 2·1, *i.e.*, 2·1 ft. aft of 'midships, and hence referring to the trim-curve this position is found to correspond to a trim by the stern of 4 ft., and thus the new position of the ship is directly obtained. This method, of course, assumes that the mean draught as obtained from the vessel's actual draughts corresponds to the even keel displacement as obtained from the displacement scale. This, of course, is tantamount to assuming that the waterplane centroid is amidships. From the ordinary principle of rotation at constant displacement (*i.e.*, Euler's theorem), it can easily be shown that with the waterplane centroid $\bar{x}$ ft. from 'midships, a correction of amount equal to $\bar{x} \cdot \frac{t}{L}$ should be made to the observed mean draught. The nature of the draught correction may be summarised as follows. To assess the true mean draught and hence displacement for a given trim, the correction should be added to the observed mean draught when the waterplane centroid is on the same side of 'midships as the preponderating draught. When the reverse is the case the correction should be subtracted from the observed mean. In starting from a known even keel draught and displacement to obtain the final draughts in a trimmed condition, the signs of these respective corrections are reversed. Mr. Long pointed out in his paper the advisability of such a correction, and gave a typical correction curve. The correction is best expressed as an increase or decrease per foot, or per 10 ft., change of trim, and can be directly obtained from the water plane-centroid curve in Fig. 2 by merely modifying its scale.

The problem of the added weight can be treated in a manner similar to that of the moved weight. The vessel's trim, true mean draught, displacement, and position of centre of gravity are noted previous to the addition of the weight. The new position of the vessel's centre of gravity, when the weight is added, is calculated, and by reference to the displacement scale, the new mean draught is read off. From the interpolated trim-line corresponding to this draught, the trim producing the required position of gravity can then be obtained. In assessing the final draughts the draught correction is in this case subtracted from the mean taken from the displacement scale, and half the trim is added to the draught aft and half subtracted from the draught forward. In using the trim-curve method it should be noticed that the necessity of imagining an added weight as being first placed over the waterplane centroid is eliminated by referring everything to the centre of gravity of the ship. The waterplane centroid only appears in the draught correction for assessing the actual final draughts. In actual practice this correction is of little importance and is generally neglected.

5. The only disadvantage possessed by trim curves is their difficulty of interpolation. This point may be of little importance to a designer in assessing trims, but it is of some importance to a captain or ship's officer who wishes to use the curves in the operating of the ship. This difficulty can be completely eliminated by recasting the trim-curves in the form of a nomogram.

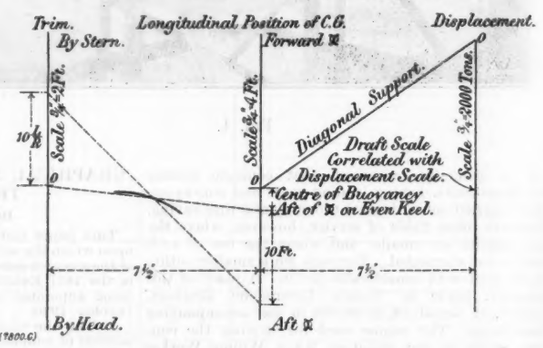
The nomographic conversion of trim-curves is greatly facilitated by the fact that the trim-line as developed by the metacentric method is straight. It can be simply shown that a straight line relation in rectangular co-ordinates is represented merely by a point when expressed in parallel co-ordinates. This property is proved in any good text book* on nomography, and only involves the geometry of similar triangles. Thus Fig. 3 shows how a trim-line is converted. Parallel scales of trim and position of centre of gravity are drawn in, the positive direction of the one being opposite to that of the other. These scales are evenly subdivided and arranged to cover the practical range of trim and centre of gravity. It will be recalled that one extremity of a trim-line corresponds to the position of zero trim and even keel position of the centre of buoyancy; and to determine the trim-line completely, the trim producing, say, a 10-ft. movement of the centre of gravity, *i.e.*, $10 \cdot \frac{R}{L}$, is set off at the correct position and the line drawn in. Similarly, these conditions are sufficient to determine the position of the trim point in Fig. 3. Thus zero trim is joined to the even keel position of the centre of gravity. Next this even keel position is increased by 10 ft., and this point is joined to the point on the trim scale corresponding to $10 \cdot \frac{L}{R}$. The intersection of these two lines gives the trim-point corresponding to the particular waterplane. This point possesses precisely analogous properties to the ordinary trim-line. By joining any position of the centre of gravity through the trim-point, the intersection of the joining line with the trim scale gives the corresponding value of the trim. The trim-points corresponding to each waterplane are obtained in a similar manner over the whole range of draughts, and form a continuous locus. This locus becomes the draught scale; and in constructing it, care is taken that each trim-point corresponds to a convenient draught so that subsequent interpolation of the draught scale is facilitated. Fig. 4 shows the complete conversion of the trim-curves shown in Fig. 2. This diagram also contains several features additional to the ordinary trim-curves. For instance, the draught correction per 10 ft. of trim obtained at each draught from the water plane-centroid curve is plotted on the draught scale. To correlate this curve an even correction is assumed, the requisite position of the waterplane centroid calculated, and then the draught noted at which this position occurs. The draught correction is then marked opposite this particular draught. This process is repeated until the whole draught range is covered. The next additional feature is a displacement scale drawn parallel to the position of centre of gravity and trim scales. The displacement is set off on an even scale, and the draught scale correlated with it. This displacement scale is not only useful for obtaining the draught corresponding to any added weight but may be simply converted into a further nomogram with the centre of gravity scale, for determining the movement of the centre of gravity consequent upon any movement of internal or added weights. A diagonal line is drawn from the zero of the centre of gravity scale to the zero of the displacement scale. The nomogram thus formed is commonly known as Z-chart, and by it, multiplication can be very simply effected. If x and y are the variables on the parallel scales, the relation

Fig. 2. TRIM CURVES. FOR INTERMEDIATE PASSENGER VESSEL 400′ × 55′ × 24′ DRAFT ·668 BLOCK COEFFICIENT.



(7800.6)

Fig. 3. KEY DIAGRAM TO TRIM NOMOGRAM IN *Fig. 4.*



(7800.6)

* "I Principali Ccefficienti Di Carena, Nella Loro Normale Associazione e Mutua Dipendenza" (*Rivista Marittima*, November, 1922).

* Cf. Brodetsky, "A First Course in Nomography." London: G. Bell and Sons.

$y = kx$ can be represented by correlating k on the diagonal scale. Thus, in the case of a centre of gravity calculation we have the following relation expressed :—

$$w \times d = \Delta \times x$$

where w = moved weight,
d = distance moved,
Δ = displacement,
x = movement of vessel's centre of gravity.

This relation may be transformed thus :—

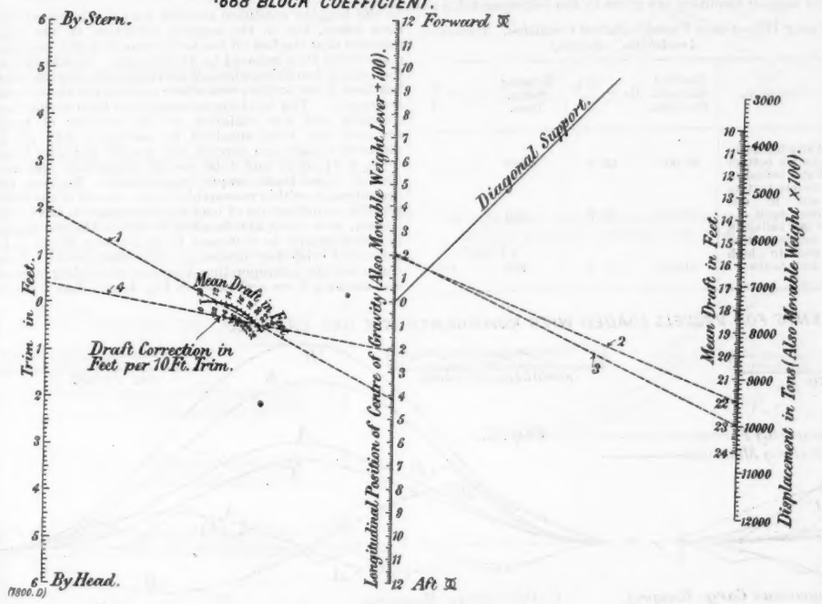
$$100\,\frac{w}{x} = 100\,\frac{\Delta}{d} = k$$

$$\therefore \quad 100\,w = k\,x \text{ and } \Delta = k \,.\, \frac{d}{100}$$

The position of the centre of gravity satisfying this trim and draught is read off, and thus the requisite shift of the centre of gravity can be obtained. This shift is joined to the 100 times the added weight, and through the intersection of the resulting line with the diagonal the value of the new displacement is joined to intersect the centre of gravity scale. The value obtained is equal to the distance, divided by 100, at which the added weight should be placed forward of the original position of the centre of gravity.

6. *Conclusion.*—To detail other particular cases would probably unnecessarily and unduly lengthen this paper. However, the author feels that the simplicity of the nomographic treatment of the trim problem as herein outlined, which eliminates arithmetic and enables a particular and oft-recurring problem to be expeditiously and accurately solved, will appeal to naval architects ;

Fig. 4. TRIM NOMOGRAM.
FOR INTERMEDIATE PASSENGER VESSEL 400'x55'x24' DRAFT
·868 BLOCK COEFFICIENT.


By Stern.
By Head.
Trim in Feet.
Draft Correction in Feet per 10 Ft. Trim.
Mean Draft in Feet.
12 Forward
12 Aft
Longitudinal Portion of Centre of Gravity (Also Movable Weight Lever ÷ 100).
Diagonal Support.
Mean Draft in Feet.
Displacement in Tons (Also Movable Weight × 100).

Now if a movement of centre of gravity x is desired with a weight w, this value of x is joined to 100 w on the displacement scale, and thus the intersection with the diagonal gives the corresponding value of k. Then, if through this intersection a line is drawn from the actual displacement, its intersection with the centre of gravity scale will give the corresponding value of $\frac{d}{100}$, and thus d, the required shift, is directly obtained. w, x and d could each be considered unknown, and obviously directly obtained from the nomogram. The factor 100 introduced here is merely, of course, to obviate the necessity of separate scales for w and Δ, and d and x. The scales adopted in the construction of Fig. 4 are given in the key diagram, Fig. 3. In a particular shipyard these scales could be standardised, and the diagram, without the draught scale, printed on stiff board. For each ship the draught scale could be drawn in very rapidly from the ordinary hydrostatic particulars available from a displacement sheet.

To illustrate the manipulation of the nomogram the example previously given for the trim-curves can be repeated. The first step is to join from the observed trim 2 ft. through the observed mean draught 22 ft. to intersect the centre of gravity scale. This intersection, as before, gives 4·2 ft. aft of 'midships. The second step is to join the displacement 9,500 tons to the value of the distance moved through by the weight divided by 100, *i.e.*, 2. Thirdly, the value of the moved weight multiplied by 100, *i.e.*, 10,000 tons, is joined through the intersection of the previous line with the diagonal scale to intersect the centre of gravity scale. This intersection occurs, as before, at a value of 2·1 ft. Thus the new centre of buoyancy is 4·2 − 2·1, *i.e.*, 2·1 ft. aft of 'midships. Fourthly, and finally, 2·1 ft. on the centre of gravity scale is joined through the mean draught of 22 ft., and the intersection with the trim scale gives, as before, a value of 0·4 ft. by the stern. In this example the draught correction only amounts to 0·12 ft. for 10 ft. change of trim, and thus for a maximum trim of 2 ft. it is unimportant.

Any other problem with a different arrangement of the variables could be equally rapidly solved by means of the nomogram. For instance, the position forward of 'midships at which a weight should be added in order that the draught aft remains unchanged can be very simply obtained. From the initial condition of the vessel the position of its centre of gravity is obtained. Next, from the displacement scale the new mean draught, after the addition of the weight, is read off, and from it the requisite trim to produce the old draught aft is noted.

it is hoped that the trim nomogram may be adopted by them, not only for ordinary drawing-office purposes, but also for presentation to ships' captains.

THE PORT OF SOUTHAMPTON.—At a recent meeting of the Institute of Transport, Major G. S. Szlumper read a paper on "The Operation of a Railway-Owned Port," which somewhat naturally was based on experience at Southampton. The author entered into the history of the port and discussed the particular conditions affecting the provision of facilities at Southampton. The bulk of the traffic being carried from the port by means of mail boats relieved the dock authorities of making much provision for warehousing, since the cargo had to be quickly cleared—either inwards or outwards. The traffic also involved special facilities for passenger and mail services which many other ports had not to consider. Major Szlumper discussed the influence of large ships on wharf arrangements, and spoke of the large project the railway company was hoping to put in hand shortly to provide adequately at the port for the increased size of modern steamers. With regard to port management the author discussed the three systems of state or public ownership, port and harbour trusts, and railway ownership, expressing a preference for the latter as the most practical.

WELDING OF A BRONZE BELL.—The big bell of the Berlin Dom (cathedral) cracked some two years ago. Although there was hardly any experience to go by as to large bronze bell welding, the Berlin firm of Sedlbauer and Sommerfeld, and A. Felix resolved to attempt welding, in view particularly of the high cost of a new bell. The operations had to be carried out in the bell-tower. The only crack visible extended from the lip vertically upward for nearly 3 ft. Chemically, the material near the crack seemed sound, but a large blow-hole was subsequently discovered, from which the crack had probably originated. The bell was placed so that the crack was uppermost, within a wall of fire brick ; a cut was made along the crack and beyond it, and the bell was slowly heated up, in 14 hours, to 500 deg. C. The weld was made with an oxy-acetylene flame. The bronze used for closing the seam was also preheated, the work was laborious and took nine hours. When the bell was examined a week later, other cracks were discovered, one being 10 ft. long, almost encircling the bell. The fire-brick wall had to be renewed and 102 kg. of bell metal were required for welding the further cracks, which had a length of about 15 ft. The note of the bell was considered to have been improved by the welding, possibly because the large blow-hole had been closed.

EFFECT OF VARIATIONS IN LOADING ON LONGITUDINAL STRUCTURAL STRESSES IN SHIPS.*

By W. THOMSON, B.Sc., Member.

ALL calculations regarding the structural stresses to which vessels are subject must, from their very nature, yield results which are comparative, and the degree to which these calculated stresses represent those actually experienced by a vessel will depend very largely on how closely the assumed conditions approximate to those which the vessel may meet in the course of its existence.

The designer presupposes a standard condition of loading, and bases his calculations on the assumption that the service conditions will not so far depart from this standard as to lead to such increases in stress as will endanger the strength of the structure. That this policy is, in general, a sound one is evidenced by the fact that the results obtained are satisfactory, and that such cases of failure as do occur can very often be traced to a distribution of cargo very different from that contemplated, and indeed very different from that which would have been adopted if only a reasonable forethought had been exercised. The purpose of the present paper is, therefore, to consider typical cases of loading which depart in some marked degree from those generally assumed and to endeavour to draw some conclusions regarding the manner in which the cargo should be disposed so as to prevent undue stresses being developed in the structure. Many assumptions must, of course, be made before it is possible to find a basis of calculation at all. Refinement of accuracy is often attempted when estimating the forces producing the stresses by making allowances for pitching, heaving and pressures in waves, but it has been shown that the stresses produced by these agencies are of minor consequence relative to a consideration of the broad factors influencing the question, and also, fortunately for the investigator of the complicated problems involved, it has been demonstrated that these secondary forces in general operate in opposing direction, and the general effect is one of annulment. It would thus appear to be not unreasonable, when considering the question on broad lines, to neglect them.

After a vessel has been completed and placed in service, the most important factor affecting the structural strength is the disposition of the cargo in a fore and aft direction, a consideration which certainly does not receive the attention which its importance warrants. The design of the vessel is left in the hands of the naval architect, but on completion the vessel passes beyond his control, and during the remainder of the vessel's life the only occasions on which he is referred to are when something goes wrong. When a cargo of an unusual nature is to be carried, he is never consulted as to the best arrangement for its stowage, so far as the strength of the ship is concerned. He is consequently very largely dependent for the success of his production upon the co-operation of shipowners and stevedores who, in the course of their business, necessarily dispose the cargo with regard to convenience of loading and discharge, and have but little opportunity of considering the possible effect on the structure of the injudicious loading which they sometimes adopt.

"Injudicious loading" is a term very difficult of exact definition, but a study of some of the diagrams and figures in this paper might enable some of the worst examples to be avoided. It may not be possible in many cases to prevent a certain degree of irregular loading, but the shipowner would be well repaid for the expenditure of a little time and thought in arranging the disposition of his cargo and would usually find it quite possible to eliminate those conditions which, by departing too far from the standard, suggest the possibility of stresses of a magnitude which may lead to failure of the structure.

It is with the intention, therefore, of throwing more light on this complex question that this investigation has been made, and in doing so the usual standard conditions for longitudinal strength calculations have been assumed, viz., in the sagging condition the vessel is assumed to be supported over the hollow of a wave whose length is equal to the length of the ship and whose height is equal to one-twentieth of its length, while in the hogging condition the vessel is poised on a wave of the same length and height with the crest amidships.

For convenience the following system of notation has been adopted :—

W = Displacement of vessel, in tons.
L = Length of vessel, in feet.
M = Maximum bending moment, in foot-tons.
S = Maximum shearing force, in tons.

C_M = Bending moment coefficient = $\frac{W\,L}{M}$.

C_S = Shearing force coefficient = $\frac{W}{S}$.

Cargo Vessels in Loaded Condition.—The possible variations in the nature and dispositions of the loads carried by the ordinary cargo vessel are almost infinite and it would be a hopeless task to endeavour to illustrate all these combinations. The condition usually assumed as a standard is that in which all the cargo spaces are filled with a uniform cargo of such density as will cause the vessel to float at her load draught. In practice the ideal of a homogeneous cargo is not often realised, for departures from this standard arise through numerous variations which are not susceptible of classification ; but it will be sufficient to select a few cases of special loading for comparison with the standard. In general it is found that, for vessels engaged in ordinary trading,

* Paper read at the Spring Meetings of the Institution of Naval Architects March 23, 1923.

the standard of strength represented by the standard conditions of loading is quite satisfactory, and this may be taken as a basis for further investigation.

As a typical example, the case of an ordinary cargo carrier of 10,000 tons cargo capacity, having the dimensions 430 ft. by 56·75 ft. by 33 ft. and a load draught of 25 ft., may be taken. In such a vessel the weights of ship and loading may be apportioned :—

	Tons.
Weight of hull	3,000
Weight of machinery	550
Weight of coal	700
Weight of cargo...	10,000
Load displacement	14,250

It has been assumed that, in the sagging condition, the total displacement is 14,250 tons as given above, and in the hogging condition that the coal has been burned out, leaving the displacement 13,550 tons.

Two conditions have been considered, (1) that the machinery is situated amidships, Fig. 1, and (2) that the machinery is fitted at the after end of the vessel, Fig. 2, and the maximum values of the bending moments and shearing forces for these conditions are given in the following table :—

TABLE I.—*Cargo Vessels. Homogeneous Cargo.*

Condition.	Bending Moment, Ft.-Tons.	$C_M = \frac{W L}{M}$	Shearing Force, Tons.	$C_S = \frac{W}{S}$
Machinery Amidships.				
Hogging ..	166,000	35·1	1,460	9·3
Sagging ..	62,000	98·7	570	25·0
Machinery Aft.				
Hogging ..	80,000	73·0	730	18·6
Sagging ..	127,000	48·3	1,300	10·9

(*a*) Ballast in double bottom tanks and peak tanks,
(*b*) Ballast in double bottom tanks and peak tanks and in one deep tank amidships.
(*c*) Ballast in double bottom tanks and peak tanks and in two deep tanks amidships.

These conditions are illustrated in Fig. 3. The same vessel has been chosen as in the previous case, and the displacements for the ballast conditions are 6,200 tons, 6,950 tons and 7,700 tons respectively, composed as follows :—

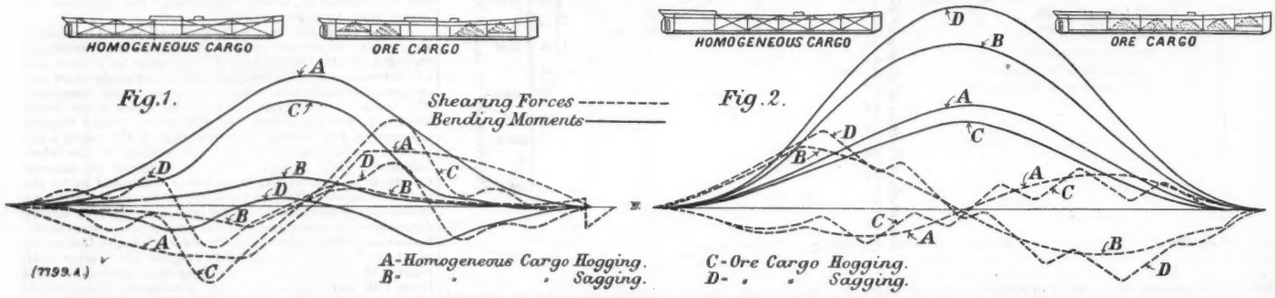
	Tons.
Weight of hull	3,000
Weight of machinery	550
Weight of coal	700
Weight of stores	250
Water ballast in double bottom ...	1,500
Water ballast in peak tanks	200
Water ballast in each deep tank ...	750

The maximum bending moments and shearing forces in the sagging condition are given in the following table :—

TABLE III.—*Cargo Vessels. Ballast Condition. Machinery Amidships. Sagging.*

Condition.	Bending Moment, Ft.-Tons.	$C_M = \frac{W L}{M}$	Shearing Force, Tons.	$C_S = \frac{W}{S}$
Water ballast in double bottom	62,000	43·0	680	9·1
Water ballast in double bottom and in one deep tank ..	77,000	38·7	840	8·3
Water ballast in double bottom and in both deep tanks ..	94,000	35·2	980	7·9

SHEARING FORCES & BENDING MOMENTS FOR VESSELS LOADED WITH HOMOGENEOUS & ORE CARGOES.



So far as cargo vessels are concerned, the most extreme cases of concentrated loading are probably to be found in vessels engaged in the carriage of iron ore in bulk, and it is thought that for present purposes it will be sufficient to compare the figures given above with those obtained under similar conditions for an ore carrier. The ore has been taken as being distributed in piles under the hatchways as shown in Figs. 1 and 2, the proportion in each hold being in accordance with general practice.

The values for the maximum bending moments and shearing forces are found to be as follows :—

TABLE II.—*Cargo Vessels. Ore Cargo.*

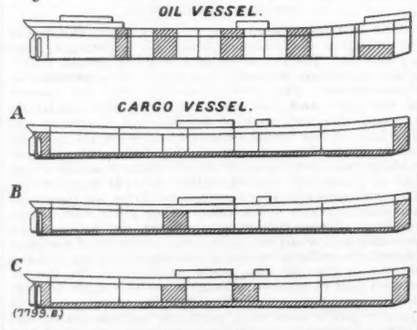
Condition.	Bending Moment, Ft.-Tons.	$C_M = \frac{W L}{M}$	Shearing Force, Tons.	$C_S = \frac{W}{S}$
Machinery Amidships.				
Hogging ..	130,000	44·8	2,150	6·3
Sagging ..	51,000	120·0	1,050	13·6
Machinery Aft.				
Hogging ..	65,000	89·8	850	15·9
Sagging ..	157,000	39·0	1,600	8·9

From a comparison of the figures given in Tables I an II, it will be observed that while the bending moments in the hogging condition are smaller for a vessel loaded with ore than in one carrying a uniformly distributed cargo, there is a decided increase in the moment in the sagging condition in the case where the machinery is fitted aft. The principal difference caused by the variation in the distribution of the cargo is to be found in the shearing forces which are in all cases greater for the ore than for the homogeneous cargo, a result which could be anticipated in view of the more concentrated nature of the cargo in the former case.

Cargo Vessels in Ballast Condition.—In order to complete the survey of cargo vessels it is necessary to take into account the bending moments experienced in the ballast condition, but these moments are, on the whole, not of a serious nature, with perhaps an exception in the case of the sagging condition. The capacity of the double bottom compartments is generally large enough to provide sufficient water ballast to ensure the requisite degree of immersion, but very often a deep ballast tank is provided in addition, and occasionally two such tanks are fitted.

In accordance with the modern practice of ballasting, a consideration of this condition should take account of the three arrangements set out as follows, namely,

Fig.3. VESSELS IN BALLAST CONDITION.



It will be observed that the bending moment with ballast in the double bottom and peak tanks only is the same as that experienced in the loaded condition. Where a deep tank is fitted, there is a marked increase in the bending moment, while in a vessel with two deep tanks the increase in the bending moment as compared with the normal load condition (sagging) as given in Table I, amounts to fully 50 per cent. An increase in moment of this magnitude calls for serious consideration, and it would appear to be necessary to pay special attention to the stiffening of the deck plating, particularly where two deep tanks of large capacity are fitted amidships.

Oil Vessels in Loaded Condition.—The problems arising in the case of oil vessels differ from those of cargo vessels on account of the homogeneous nature of the cargo carried and the facility with which it can be distributed into the different tanks in the vessel. In this case, therefore, no complications of loading arise through the necessity of cargo being stowed to suit convenience of discharge at a number of ports of call, and greater regard can be paid to the desirability of arranging its most suitable disposition as regards the structural strength of the vessel.

Oil vessels are, as a rule, designed for cargoes of petroleum, but sufficient capacity is usually provided to enable a full deadwright cargo of the lightest type of oil to be carried. Since the specific gravity of liquid cargoes varies from 0·74 in the case of petrol, to 0·96 for fuel oil, and 1·25 for molasses, it is evident that many voyages will be made in which it will not be possible to fill all the tanks completely. As it is not considered wise to make a voyage with tanks only partly filled, it follows that one, two or more tanks will be empty. The choice of tanks which are to be filled is one which should receive very careful consideration and should not be treated in the haphazard manner which is apparently sometimes adopted. For purpose of comparison with corresponding cargo vessels, an oil ship of the same dimensions as the cargo vessel dealt with previously, viz., 430 ft. by 56·75 ft. by 33 ft., draught 26 ft., and having machinery aft, has been chosen, the principal particulars being :—

	Tons.
Weight of hull	3,700
Weight of machinery	550
Weight of fuel oil	650
Weight of cargo oil	9,350
Local displacement	14,250

In the hogging condition the full load displacement has been taken, but in the sagging condition it has been assumed that the fuel oil has been consumed, the displacement being thus reduced to 13,600 tons. In addition to the normal condition when all tanks are full, consideration has been given to the cases where one, two or three tanks are empty. The total displacement has been maintained constant and the variation in the number of tanks required has been obtained by assuming that oils of different density are carried, the specific gravities being 0·73, 0·81, 0·91 and 1·04 for all tanks full, and one, two or three tanks empty respectively. To keep the investigation within reasonable limits, several of the many possible combinations of loading arrangements have been chosen, and these are detailed in Table IV, the figures in which should be sufficient to enable any others to be estimated with fair precision. The distribution of the cargo and the corresponding diagrams of bending moment and shearing force are shown in Fig. 4, and Figs. 5 and 6.

Since the maximum moments occur when the vessel is in the sagging condition, examples of hogging are only given for the worst conditions in each case :—

TABLE IV.—*Oil-Carrying Vessels. Loaded Condition.*

Condition.		Bending Moment. Ft.-Tons.	$C_M = \frac{W L}{M}$	Shearing Force, Tons.	$C_S = \frac{W}{S}$
All tanks full ..	..Hogging	20,000	293·0	420	32·3
All tanks full ..	..Sagging	180,000	34·1	1,840	7·7
One tank empty :					
Midship tank empty..	Hogging	48,000	122·0	860	16·8
Midship tank empty..	Sagging	160,000	38·3	1,570	9·1
End tank empty ..	Sagging	200,000	30·6	2,100	6·8
Two tanks empty :					
Two adjacent midship tanks empty..	..Hogging	87,600	66·7	1,260	10·8
Two adjacent midship tanks empty..	..Sagging	155,000	39·5	1,780	8·0
Two alternate midship tanks empty ..	..Sagging	160,000	38·3	1,770	8·1
One midship and one tank empty ..	..Sagging	165,000	37·2	1,950	7·3
Two adjacent end tanks empty ..	..Sagging	206,000	29·7	2,260	6·3
One tank at each end empty ..	..Sagging	240,000	25·5	2·500	5·7
Three tanks empty :					
Three adjacent midship tanks empty..	..Hogging	109,000	52·7	1,840	7·4
Three adjacent midship tanks empty..	..Sagging	115,000	53·3	1,680	8·4
Three alternate midship tanks empty	..Sagging	130,000	47·2	1,720	8·3
Two adjacent and one midship tank empty	Sagging	162,000	37·9	2,040	7·0
One amidships and one at each end empty	..Sagging	214,000	28·7	2,390	6·0
Two aftermost and foremost empty	....Sagging	256,000	23·9	2,850	5·0

The figures given in this table are worthy of very careful study as showing the great variations in bending moment and shearing force which directly result from change in the position of the empty tanks. If the condition of the vessel, with all tanks full, be regarded as the standard, it will be observed that it is always possible, in cases where one or more tanks are empty, so to load the vessel that the resulting bending moment in the

sagging condition (which in vessels of this type is much more important than the hogging) will be less than the standard, while, on the other hand, by an injudicious arrangement of loading, bending moments very much in excess of the standard are developed. As might be anticipated with increased concentration of cargo amidships, both the bending moments and shearing forces increase very rapidly until in the last example quoted the bending moment is 42 per cent. and the shearing force 55 per cent. greater than in the standard.

The fact that certain distributions of cargo cause bending moments and shearing forces less than those in the standard condition naturally leads to the question as to what is really the best arrangement to be adopted. To determine this, attention must be paid to the various factors which influence the structural strength, although, as regards the sagging condition, it is clear that the best disposition of the cargo is to have the empty tanks amidships and adjacent. This arrangement, however, produces increased stresses in the hogging condition and also leads to considerable increases in the structural shearing forces. In addition, severe local stresses may be caused by the abrupt changes in the loading. On the whole it would appear that, taking everything into account, the most satisfactory solution would be to arrange the empty tanks alternately amidships.

Oil Vessels in Ballast Condition.—The amount of ballast usually carried by a tanker varies to a certain extent with the route on which the vessel is engaged, but, for a vessel of the dimensions considered, 3,000 tons of ballast in addition to the oil fuel may be accepted as average practice, the displacement being about 7,850 tons. With the ballast distributed in three tanks, say, Nos. 2, 5 and 8, as shown in Fig. 3, the bending moments and shearing forces would be as given in Table V.

The bending moment and shearing force are therefore not of sufficient magnitude to cause any anticipation of trouble when the vessel is in the ballast condition, provided a reasonable distribution of ballast is adopted.

TABLE V.—*Oil-Carrying Vessels. Ballast Condition.*

Condition.	Bending Moment, Ft.-Tons.	$C_M = \frac{W L}{M}$	Shearing Force, Tons.	$C_S = \frac{W}{S}$
Hogging ..	100,000	43·7	1,200	65·5
Sagging ..	82,400	41·0	1,060	74·0

Stresses Due to Longitudinal Bending.—Having obtained the bending moments and shearing forces to which ships may be subjected under varying conditions of loading, the next step is naturally to determine the stresses produced in the structure by these moments for vessels of different length. In Table VI are set forth the calculated stresses in the hogging condition for cargo vessels of 300 ft., 400 ft. and 500 ft. length, having the machinery amidships and loaded with a uniformly distributed homogeneous cargo. The moment of inertia and modulus of resistance have been calculated in the usual units for

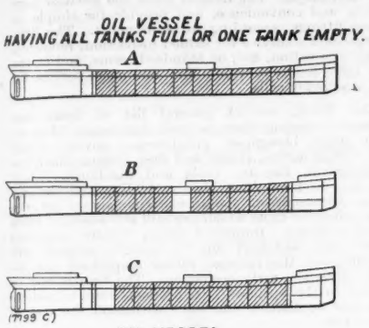
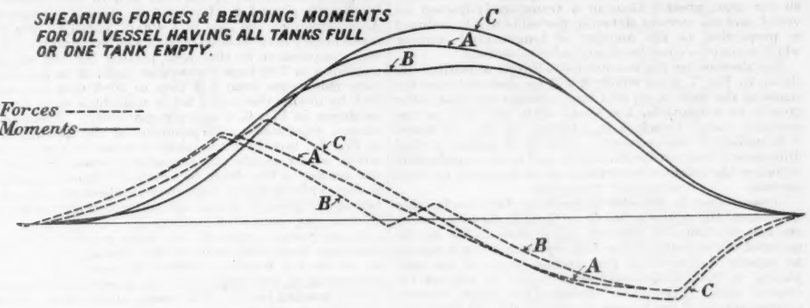


Fig.4. SHEARING FORCES & BENDING MOMENTS FOR OIL VESSEL HAVING ALL TANKS FULL OR ONE TANK EMPTY.



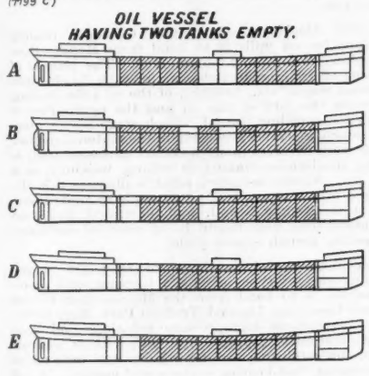
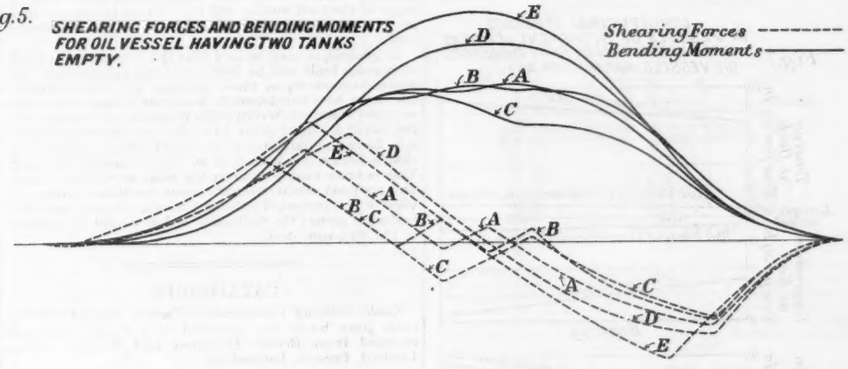


Fig.5. SHEARING FORCES AND BENDING MOMENTS FOR OIL VESSEL HAVING TWO TANKS EMPTY.



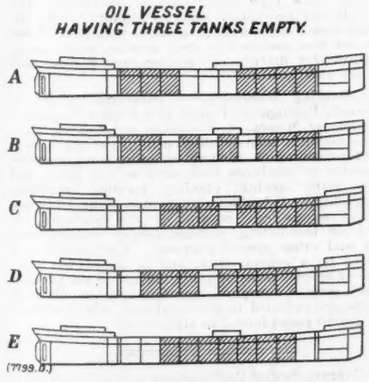


Fig.6. SHEARING FORCES AND BENDING MOMENTS FOR OIL VESSEL HAVING THREE TANKS EMPTY.

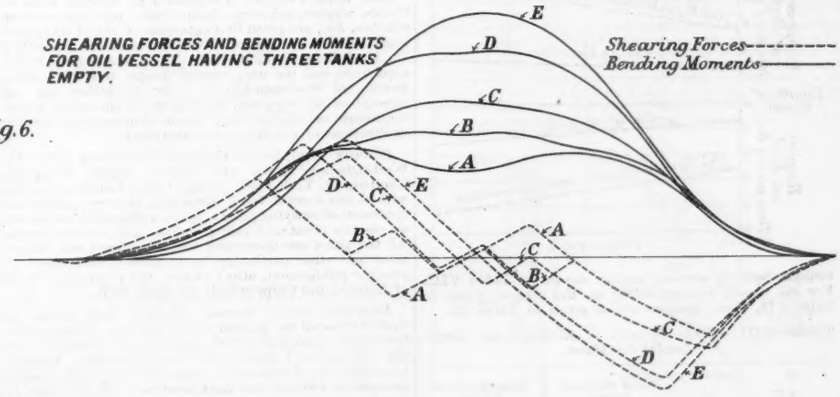


TABLE VI.—CARGO VESSELS. MACHINERY AMIDSHIPS. HOMOGENEOUS CARGO—LOADED CONDITION.

Dimensions of Vessel, Ft.	Draught, Ft.	I, Sq. In. × Ft.²	$\frac{I}{y}$ Deck, Sq. In. × Ft.	$\frac{I}{y}$ Keel Sq. In. × Ft.	Hogging. Tension at Deck, Tons per Sq. in.	Hogging. Compression at Keel, Tons per Sq. In.	Sagging. Compression at Deck, Tons per Sq. in.	Sagging. Tension at Keel, Tons per Sq. In.
300 × 42 × 24	20·5	88,000	6,000	9,350	7·4	4·77	2·58	1·65
400 × 53 × 32	25·6	275,000	15,500	20,000	8·2	6·10	2·86	2·30
500 × 64 × 40	30·7	684,000	31,700	37,000	9·0	7·7	3·54	3·0

TABLE VII.—OIL-CARRYING VESSELS. MACHINERY AFT. TRANSVERSE CONSTRUCTION—LOADED CONDITION.

Dimensions of Vessel, Ft.	Draught, Ft.	I, Sq. In. × Ft.²	$\frac{I}{y}$ Deck Sq. In. × Ft.	$\frac{I}{y}$ Keel Sq. In. × Ft.	Hogging. Tension at Deck, Tons per Sq. In.	Hogging. Compression at Keel, Tons per Sq. In.	Sagging. Compression at Deck, Tons per Sq. In.	Sagging. Tension at Keel, Tons per Sq. In.
300 × 42 × 24	20·5	105,000	8,360	9,150	0·7	0·6	5·7	5·2
400 × 53 × 32	25·6	295,000	17,600	19,300	0·8	0·7	7·5	6·8
500 × 64 × 40	30·7	715,000	32,100	36,300	1·1	1·0	9·6	8·5

a section in way of the upper deck and through a hatchway, no allowance being made for the rivet holes. The values of y have been taken to the top of the keel and the underside of the deck stringer plate, and the scantlings are assumed to be in accordance with the current practice of Lloyd's Register (see Table VI). In the case of oil vessels having the machinery aft, the sagging condition is the more severe, and the calculated stresses for oil vessels in the standard condition of loading are given in Table VII. The stresses thus indicated refer to vessels framed on the ordinary transverse system. In vessels built with longitudinal framing, the modulus of resistance —if full credit be taken for the longitudinals—is about 30 per cent. greater than in a transversely-framed oil vessel, and the stresses shown in the table will be reduced in proportion to the amount of longitudinal framing which it may be considered advisable to include.

The stresses for the standard conditions of loading are shown in Fig. 7, from which it will be observed that the stress at the deck in oil and cargo vessels does not differ greatly in magnitude, but that, while the deck of the ordinary cargo vessel is in tension, in the oil vessel it is subject to compression. This is, of course, a vital difference in a structure like a ship and must considerably influence the relative importance to be attached to these stresses.

Stresses Due to Structural Shearing Forces.—In ship structures, the stresses due to structural shearing forces are not generally of primary importance so far as the material of the hull is concerned, but may become serious as regards the rivets in the landing edges of the shell plating in the forward and after bodies in way of the neutral axis. The shear stresses for cargo vessels, corresponding to the figures given in Table VI for longitudinal bending stresses are as shown in Table VIII. For oil vessels corresponding to the figures given in Table VII, these stresses are as given in Table IX.

Fig. 7. LONGITUDINAL STRESSES IN VESSELS OF DIFFERENT LENGTHS. CARGO VESSELS MACHINERY AMIDSHIPS. OIL VESSELS MACHINERY AFT.

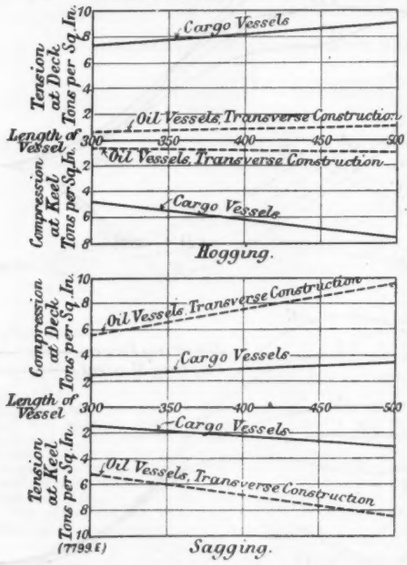


TABLE VIII.—*Cargo Vessels. Homogeneous Cargo. Loaded Condition.*

Dimensions of Vessel, Ft.	Draught, Ft.	Shear Stress on Plating, Tons per Sq. In.		Shear Stress on Rivets, Tons per Sq. In.	
		Hogging.	Sagging.	Hogging.	Sagging.
300×42×24	20·5	2·25	0·90	3·52	1·41
400×53×32	25·6	2·85	1·11	5·30	2·05
500×64×40	30·7	3·52	1·86	7·08	2·82

TABLE IX.—*Oil-Carrying Vessels. Transverse Construction. Loaded Condition.*

Dimensions of Vessel, Ft.	Draught, Ft.	Shear Stress on Plating, Tons per Sq. In.		Shear Stress on Rivets, Tons per Sq. In.	
		Hogging.	Sagging.	Hogging.	Sagging.
300×42×24	20·5	0·6	2·6	0·8	3·6
400×53×32	25·6	0·8	3·6	1·3	6·0
500×64×40	30·7	1·0	4·5	1·65* / 1·10	7·5* / 5·0

* These figures refer to stresses in double and treble riveted seams respectively.

Conclusions.—The figures given for the calculated stresses in Tables VI to IX refer, as previously mentioned, to vessels with a uniformly distributed cargo, supported on a wave whose length is equal to one-twentieth of the length. The figures clearly show that as the length of the vessel increases, so does the calculated stress, and a point will be reached where this figure exceeds what might be considered a safe limit if regarded only from a paper standpoint. Since, however, experience has shown that vessels having calculated stresses of this order are perfectly satisfactory, it may be inferred that the assumed conditions are certainly too severe in the larger vessels.

The principal object of this paper is to draw attention to the results which may follow a departure from the standard conditions of loading, and in this connection the figures given for oil vessels are specially instructive. As an example, the case of a 400-ft. vessel having three tanks empty may be cited, and it will be found that, while the compression in the deck plating for the standard condition is 7·5 tons per square inch, it is possible to vary this figure from 4·8 tons to 10·6 tons per square inch by having the empty tanks amidships, or at the ends as shown in Fig. 6, A and E respectively. There are, of course, objections to the adoption of the loading shown in Fig. 6A, but there are many alternative arrangements which would enable the excessive stresses produced by the loading in Fig. 6E to be avoided. This is admittedly a somewhat extreme case, but it illustrates the possibilities for mischief due to lack of forethought on the part of those responsible for loading.

Cargo vessels present the same marked differences resulting from variation in the stowage of the cargo so far as the bending moment is concerned, but concentration of the cargo leads to a pronounced increase in the shearing forces. For vessels about 400 ft. in length carrying ore, the shear stress on the rivets in the landing edges of the shell plating will be 7·7 tons per square inch as compared with 5·3 tons for a uniformly distributed cargo.

In general, it may be said that the structure of vessels as usually built will be found to fulfil satisfactorily the demands made upon them provided the distribution of the cargo does not depart in too great a degree from the assumed standard, but in order to secure the best results, the naval architect must have the co-operation of those who have the handling of the vessel after completion so that extreme conditions of all kinds may be avoided. This is truer to-day than in the past, as modern vessels are designed upon scientific considerations, which, in view of the increased efficiency in the disposition of the material, permit the utilisation of less weight of material in the structure itself.

CATALOGUES.

Cable Jointing Compounds.—Various compounds for cable joint boxes are described in a 4-page catalogue received from British Insulated and Helsby Cables, Limited, Prescot, Lancashire.

Steel Rope Fittings.—Particulars of fittings such as blocks, nippers, grippers, clamps, reels, log lines, cutters, winches, &c., are given in a catalogue of about 60 quarto pages issued by Messrs. Bullivant and Co., Limited, 72, Mark-lane, London, E.C. These apparently rough appliances call for very careful design, and the highest quality of workmanship in order to utilise the full strength of the rope and to provide for the many severe conditions of marine use. Some illustrations showing applications of the fittings are included.

Railway Equipment.—Catalogues received from the Westinghouse Brake and Saxby Signal Company, Limited, 82, York-road, King's Cross, London, N., deal with direct-current track circuiting, electric control and operation of outlying points by low-voltage direct-current, an electric point and lock machine, and electric signals. All the gears are illustrated and fully described, dimensions and other particulars being given in each case. In another publication, also to hand, the company's works at London and Chippenham are dealt with.

Furnaces.—Large heating furnaces and ovens are well illustrated by general views and line drawings in a handsome catalogue of 90 quarto pages received from the Dowson and Mason Gas Plant Company, Limited. Levenshulme, Manchester. Steel melting, ingot soaking, re-heating, forging, and heat-treatment are provided for and furnaces for guns, sheets and tin plates, wire annealing tube welding and other special processes are also dealt with. Some of the furnaces shown are specially designed for boiler shops, shipyards, glass works, pottery kilns and other industries. In all cases complete fittings for easy working, loading, regulation, &c., are incorporated in the design.

Central Exhaust Steam Engines.—The central exhaust or "uniflow" engine is acquiring a prominent place among modern prime movers for reasons which are well explained in a catalogue received from Messrs. Hicks, Hargreaves and Company, Limited, Bolton, Lancashire, who are producing these engines in a series of 14 powers, ranging from 150 h.p. to 1,200 h.p., in addition to special designs. The cylinders for the powers mentioned range from 15 in. to 41 in. in diameter, and all the engines are of the single-cylinder, condensing, horizontal type, suitable for a boiler pressure of 180 lb. per square inch. The catalogue fully describes the essential parts of the engines.

Propellers, Pumps, &c.—A catalogue of bronze propellers made by Messrs. J. Stone and Co., Limited, of Deptford and Charlton, London, is handsomely illustrated with reproductions of naval ships which have been equipped by them. Others on pumps, ship fittings, watertight doors and train lighting equipment give all the information required by engineers and naval architects for the selection of suitable plant for any particular application. They are all well-illustrated with photographic reproductions and diagrams. A list of nails, screws and rivets in copper, brass, zinc and aluminium conveys an idea of the great variety of such products manufactured at the Deptford works.

Lifts.—The catalogue of lifts issued by Messrs. Waygood-Otis, Limited, 54, Fetter-lane, London, E.C., deals with nearly every known type from the smallest hand-power service lift, to those for passengers and goods, motor cars, &c.; moving stairs, or escalators, are also referred to. The majority of the lifts are operated by electric power, but hydraulic lifts still have a certain field of usefulness. The designs show the greatest care for safety and convenience, and provide for simple or luxurious fittings, according to reqirements. The firm have organised a service for skilled inspection, renewals, cleaning, lubrication, &c., on standard terms, and in the case of large towns provide a day and night service for special emergency calls.

Smiths' Tools, &c.—A general list of tools and appliances, including vices, bellows, fan forges, blowers, brazing pans, blowpipes, grindstones, anvils, swage blocks, surface tables, stocks and dies, forging machines and apparatus, foundry tools and machines, lifting tackle, &c., to hand from Messrs. Alldays and Onions, Limited, Birmingham, contains particulars of all the various primitive tools which are still the essential basis of metal working. Improved forms, greatly improved materials and additions due to modern progress are noticeable, but the changes rather emphasise our indebtedness to the early craftsmen. The firm is one of the oldest in the business. Its products seem to include all the new appliances that have withstood the test of practical use.

Oil Mill Machinery.—A notable catalogue dealing with plant for oil mills is to hand from Messrs. Rose Downs and Thompson, Limited, Hull. The process of extracting oil from seeds, nuts, &c., may be divided into three main stages, viz., breaking of the oil cells, heating to promote the flow of the oil and the application of pressure for expelling the oil. Each stage may require one or several machines according to the material treated, and the work involves many auxiliary processes such as washing, deodorising, caking or cubing, weighing, sack filling, &c. All the necessary plant is illustrated in the catalogue, which is an excellent example of trade literature. It is strongly bound, well illustrated, has good explanatory text, and should be of material assistance in extending British export trade.

Steam Turbines.—A catalogue of 88 pages quarto, describing various types of steam turbines with ample illustrations, is to hand from the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester. Types classified as high-pressure reducing, and back pressure, and mixed pressure, are dealt with in separate parts of the catalogue, and other parts deal with recent developments, feed-heating systems and gearing. A full and clear description of construction is given with detailed information as to the economies which may be effected by each type under various conditions. The lists of electric generating stations equipped with the firm's turbines show a wide range of powers from 25,000 kw. to 250 kw. and a few even smaller, while many installations for driving air compressors, blowers and pumps are also listed.

Wood-Working Machinery.—A catalogue printed in the Spanish, Portuguese, French and English languages, and issued by Messrs. A. Ransome and Co., Limited, Newark-on-Trent, is an excellent example of the class of trade literature which is likely to bring foreign orders. The number of machines dealt with is very large, and includes many sawing, planing, turning, moulding, jointing, boring, sand-papering, saw sharpening, and other tools and accessories. Several of the machines are adapted for tree-felling, railway sleeper cutting, cask making and other special purposes. Each machine is illustrated by a general view, and in some cases illustrations of special parts of the machine or the product are also given. Complete specifications in all four languages are included in the catalogue, which extends to 145 quarto pages bound in stiff covers.

THE COEFFICIENT OF CONTRACTION IN GAS DISCHARGE.—Availing themselves of the opportunity given by the erection of a large dry gasholder, of a capacity of 20,000 cub. m. (about 700,000 cub. ft.), Drs. Schwarz and Wengl, of the Gute Hoffnungshütte, made a series of measurements of the coefficient of contraction of nozzles formed in diaphragms of large-size mains, up to 5 ft. in diameter. The actual pipe diameters were 595 mm., 995 mm. and 1,495 mm. (*Zeitschrift Verein. Deutsch. Ingenieure*). The nozzles were all supposed to be curved to circular arcs, but were not of perfect curvatures; they ranged in internal diameters from 346 mm. up to 1,248 mm.; the diaphragm diameters had similar extreme ranges. Pressures were determined in front of, and behind, the diaphragms at distances of 80 mm., 130 mm. and 450 mm. from the nozzles (roughly 3 in., 5 in., 18 in. respectively). The rate of gas flow was determined and checked by leakage tests, before and after each series of measurements. The results lead to the empirical formula $\mu = 1 - 0{\cdot}368\sqrt{1{\cdot}15 - m^2}$, where μ is the coefficient of contraction, usually designated by C*c* in this country, and $m = f/F$, *i.e.*, the ratio of the cross-section of the nozzle or diaphragm to that of the pipe. Up to $m = 0{\cdot}75$ the observations agreed with the formula and gave an elliptic curve; when m became greater than 0·75, the agreement was less satisfactory. For $m = 1$, μ should also be 1; the actual coefficient observed was about 0·93. The coefficient of contraction appeared to be independent of the pipe diameter, at least, up to diameters of 5 ft.

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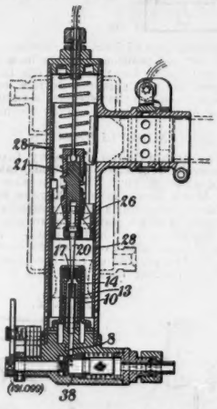
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

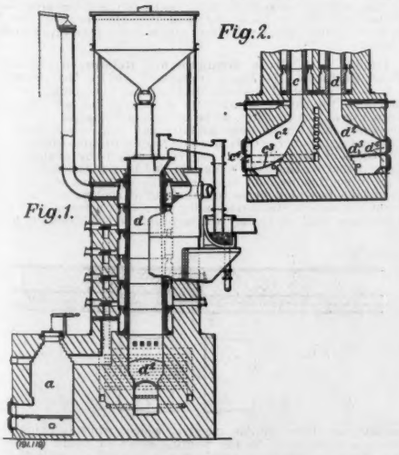
GAS ENGINES, PRODUCERS, HOLDERS, &c.

191,099. W. H. Eames, London, W. Ll. Morgan, London, and W. Dyson, London. Carburettors. (4 *Figs.*) August 4, 1921.—The invention relates to carburettors. According to the invention, the petrol nozzle 17 is surrounded by an annular air supply conduit 13 formed by and between a conduit 10 through which petrol passes to the petrol nozzle 17 and a surrounding shell 14. The upper end of the conduit 13 is closed except for an annular row of outlet orifices consisting of radial slots or grooves inclined towards the issuing jet of petrol, so that the jets of air impinge upon the jet of petrol as it issues from the petrol nozzle 17,



break it up and facilitate the production of an efficient explosive mixture. The petrol nozzle 17 is controlled by a needle valve 20, which is mounted in a member 21 by which the throttle sleeve 28 is adjustable. The needle valve 20 is associated with a spring 26 that normally holds in its lowest position relatively to the member 21. With advantage the bottom of the carburettor is formed as a casing in which works a conical valve 38 having a series of graduated ports working opposite to a vertical inlet port or passage 8 through which petrol is supplied to the petrol nozzle 17. (*Accepted January* 17, 1923.)

191,119. E. J. and J. Pearson, Limited, Stourbridge, and J. C. Deely, Stourbridge. Gasification of Coal. (3 *Figs.*) June 20, 1922.—The invention relates to the gasification of coal in retorts of the vertical type. The invention provides an apparatus employing one or more gas producers *a* and two or more vertical retorts *c*, *d* built as a single structure, and the distinctive feature of the invention consists in that each retort *c* or *d* extends downwardly into a lower chamber c^2 or d^2 arranged low down in the base of the apparatus, which chamber

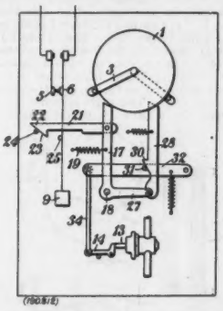


is provided with a side exit c^4 or d^4 for emptying and for interchange of a closed bottom c^3 or firebars d^3 in the base of the chamber. A steam supply is arranged below the fire-bars d^3. The arrangement provides that the retorts can either all work for the complete gasification of coal or for the production of straight coal gas, or so that straight coal gas may be produced in one of the retorts and a gas resulting from a complete gasification of coal in another or others of the retorts, and *vice versa*. The various gasification processes are due to the interchangeability of the closed bottom and fire-bars of the lower chambers. It will be understood from the drawings that the arrangement illustrated is an apparatus which can generate three different gases simultaneously, namely, water gas in the producer *a*, straight coal gas in the retort *c*, and a gas resulting from complete gasification in the retort *d*, so that the heating effects of the producer in relation to the retorts is only needed in the heating chamber of the retort *c*, although, if desired, both retorts may be arranged for the generation of straight coal gas, in which case the same producers, or two producers, would be used, one for each retort. (*Accepted January* 17, 1923.)

191,124. S. Williams, Lytham. Internal Combustion Engines. (5 *Figs.*) September 20, 1921.—The invention relates to a device through which air passes to the engine cylinder or cylinders or to the induction pipe between the carburettor and the cylinders of an internal-combustion engine. According to the invention, air is drawn by the motion of the piston or pistons in the engine cylinder or cylinders into a device A comprising

an outer chamber and an inner chamber, both of which have inlet holes *a* in their upper portions through which air is drawn into the induction pipe and passes with the carburetted air to the engine cylinder or cylinders. The device is mounted on the instrument board of a motor road vehicle and is connected by a pipe a^1 with the induction pipe. A cock or valve is also fitted between the device and the cylinder or cylinders to regulate the inflow of air to the engine. (*Sealed.*)

190,812. R. C. Graseby, Westminster, London. Igniting Mechanism for Gas Burners. (1 *Fig.*) September 30, 1921.—The invention relates to mechanism for effecting electrically the ignition of gas burners of the type in which the ignition circuit is normally open and is arranged to be intermittently closed by a vibrating spring arm at or for a certain interval of time from the time at which the supply valve for the gas is opened in order to enable the supply of gas to the burner to be fully established and the air expelled from the pipe through which the supply of gas is effected. According to the invention, the improved mechanism comprises a simple pendulum device 9 which, when in its normal position of rest, interrupts the ignition circuit at 5, 6, and is arranged to be displaced by clock mechanism 1 and released upon the opening of the gas valve by this mechanism, the movement of the pendulum being arranged to cause the ignition circuit to be intermittently closed until the oscillations of the pendulum have become reduced in amplitude to a predetermined extent. Assuming that the parts are in the position shown, and the actuating arm 3 of the clock mechanism is brought into engagement with the upper extremity of the bell crank lever 17, the continued movement of the actuating arm 3 in a counter clockwise direction will effect the rotation of the bell crank lever 17 about its point of support in opposition to the action of the spring 19. The lever 21 will consequently be moved to the right, disengaging itself from the projection 24 and engaging with the projection 25 on the flexible element of the pendulum 9. This movement of the bell crank lever 17 acting through its short



arm 27 will simultaneously effect the downward movement of the lever 28 until the projection 30 thereon engages with the underside of the projection 31 formed on or attached to the lever 32. At this stage the pendulum 9 is held by the lever 21 in one of its extreme positions. When the actuating arm 3 arrives at a position in which it is clear of the upper extremity of the bell crank lever 17, this lever will return to its position under the action of the spring 19, and the inclined face 23 of the enlarged head or projection 22 of the lever 21 engaging with the stop 24, the lever 21 will be moved out of engagement with the stop 25 and the pendulum 9 will commence a series of oscillations effecting a continuous make and break between the contacts 5 and 6, and a consequent continual opening and closing of the ignition circuit, until the oscillations of the pendulum have become reduced in amplitude to a predetermined extent. Furthermore, the return of the bell crank lever 17 to its normal position effects the quick upward movement of the lever 28 and the projection 30 thereon being in engagement with the projection 31 on the lever 32 this lever is rotated about its point of support, thereby raising the lever 34 and, acting through the bell crank lever 14, depressing the stem 13 of the gas valve and permitting the free passage of gas to the burner. The pendulum 9 will continue to oscillate for an interval of time sufficient to establish the free flow of gas through the burner, the lighting of the burner being insured by this intermittent opening and closing of the ignition circuit, which continues until the oscillations of the pendulum have been reduced to within very narrow limits, dependent upon the adjustment of the contacts 5, 6. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

191,165. W. G. Harris, Bristol, A. J. Owen, Redfield, Bristol, and H. G. Vassall, Bristol. Hand-Propelled Trucks. (3 *Figs.*) October 7, 1921.—The invention relates to hand-propelled trucks and trollies. According to the invention, the chassis of the truck comprises a frame, three or more wheel units mounted on pivots on the frame, a table or platform on which the tray or bin is carried mounted on a pivot on the frame, and means for turning the wheel units about their pivots simultaneously in the same direction. In one form of truck made in accordance with the invention, four pairs of wheels *b* mounted on axles *c* are used. The axles *c* are pivotally mounted on brackets *d*, which are mounted on pivots on a frame *a* so that lines joining their centres of rotation would form a square. On the pivot of each bracket is mounted a gear wheel *k*. An auxiliary frame *z* is secured to the main frame by four bolts and spaced therefrom which bolts form bearings for four intermediate wheels *m*. Each intermediate wheel *m* meshes with one of the wheels *k*. A table or platform *e* is mounted on a pivot in bearings *h*, *g* in the frame *z* and main frame *a*, and is provided

Fig.1.

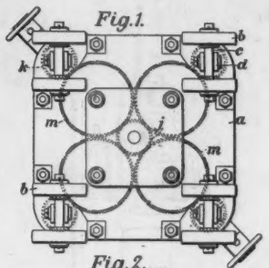


Fig.2.

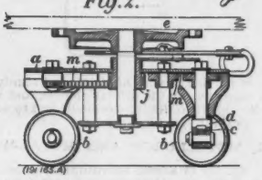
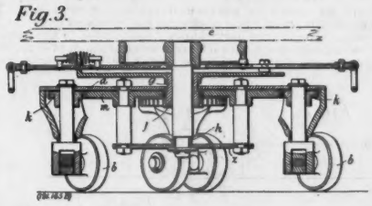


Fig.3.



with a gear wheel *j* which meshes with the four gear wheels *m*. In use all the wheels *b* will lie in the same direction and the truck is guided by turning the table or platform *e*. The gear wheels *k* on the forked brackets *d* and the gear wheel *j* are preferably all the same size. The axles of the wheels are pivoted to the forked brackets so that the wheels may rock, or tilt laterally, to conform with any inequalities in the floor. (*Sealed.*)

191,090. H. S. Taylor, Basford, Stoke-on-Trent, and W. P. Taylor, Basford, Stoke-on-Trent. Rope Haulage System. (5 *Figs.*) July 2, 1921.—The invention relates to couplings for haulage rope systems of the type in which a wire rope is employed for hauling the running head or carriage from which the load is suspended, such carriage being provided with a clip to enable the hauling rope to be gripped or released when required. The invention consists of a carriage frame *d*, supported on the fixed track *b* by one or more pulleys d^1 running thereon, having a swivelling arm or arms *g* carrying the usual clip device *i* at its upper end adapted to move from one side of the track *b* to

Fig.1.

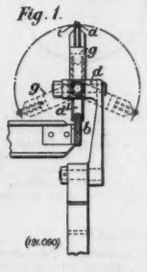


Fig.2.

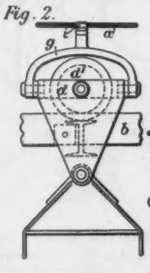


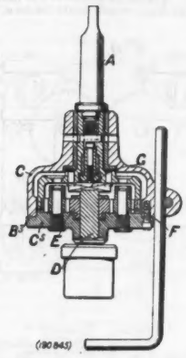
Fig.3.

the other about an axis in the line of and above the fixed track and in a direction transversely to that in which the carriage *d* is moving, so that at all times such swivelling arm or arms *g* can readily conform to the direction of the hauling rope *a* without strain. A further feature of the invention is to connect the swivelling arm *g* to the clip device *i* by means of a telescope member *k* which can move within a limited range so as to increase or decrease the distance between the axial centre of the supporting pulley or pulleys d^1 and the hauling rope *a*, where the hauling rope and the track differ in their distances from each other. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

190,845. Sir A. Herbert, Dunley Manor, near Whitchurch, and P. V. Vernon, Keresley, near Coventry. Screw Threading Mechanism. (3 *Figs.*) October 21, 1921.—The invention relates to tapping or the like screw threading mechanism of the kind in which the tap-carrying spindle D is axially movable in relation to the driving member A and is provided with clutches G adapted at one end of its axial travel to engage it directly with the driving member, thereby to rotate with the latter at the same speed and in the same direction during the tapping operation, and at the other end of its travel to engage with a loosely mounted and concentrically-arranged gear wheel E which is driven through an intermediate wheel F by an internally-toothed gear B^3 carried by the driving member, thereby to be rotated in a reverse direction at a higher speed to effect the withdrawal of the tap. According to the invention, the gear mechanism is enclosed within a non-rotating casing constituted by two parts only, whereof one is in the form of an inverted cup C concentric with the driving and driven spindles and completely

surrounding the said gears, and the other is a plate C5 attached to the mouth of the cup and forming the sole support for a fixed spindle (or spindles) for the intermediate gear or gears F. Thus



it is possible to provide a casing of simple and sturdy form which can be well supported by the driving spindle, and will thus act to give ample support to the driven spindle and to maintain it in alignment. *(Sealed.)*

MINING, METALLURGY AND METAL-WORKING.

190,833. W. M. O'Keefe, Birmingham, and A. James, Aston, Birmingham. Mechanical Riddles for Foundries. (3 *Figs.*) October 7, 1921.—The invention has for its object to provide an improved mechanical riddle for foundries. The invention comprises a pair of circular riddle frames or supports *e* adapted to receive ordinary riddles *f* and carried in the same or different planes on opposite sides of a vertical standard *b*, together with a crank *g* and connecting rod *h* or any other suitable

Fig. 1.

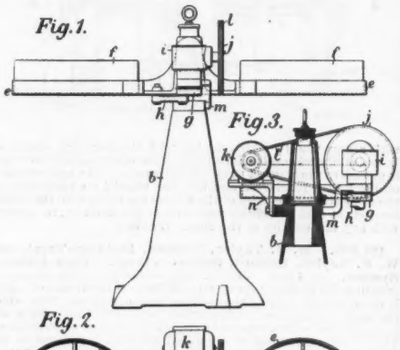
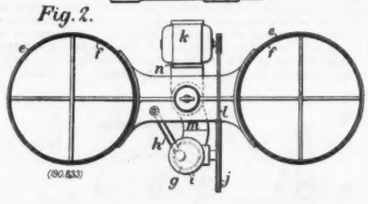


Fig. 3.

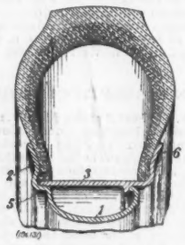
Fig. 2.



mechanism for imparting horizontal oscillatory movements to the frames *e*. The crank *g* and connecting rod *h* are driven through gearing contained in a box *i* from a wheel *j*. The latter is rotated from an electric motor *k* through a belt *l*. The gear-box *i* is carried on a bracket *m* at the upper end of the standard *b*. The electric motor is carried on an extension *n* of the bracket, the motor and gear box being situated at opposite sides of the standard. *(Sealed.)*

MOTOR ROAD VEHICLES.

191,131. S. A. Currin, Sydenham, London. Pneumatic Tyred Wheels. (1 *Fig.*) October 3, 1921.—The invention relates to wheels for pneumatic tyres of the type wherein one tyre retaining flange is formed integrally with, or permanently secured to, the felloe, and the other is connected integrally with a split ring like member which is threaded on to the felloe and is held against axial displacement from the felloe by means of the



inter-engagement of a circumferential projection and recess. According to the invention a wheel of the type described has a ringlike member 3 extending across the felloe 1 as far as the other tyre-retaining flange 2 so as to be engaged by both edges of the tyre cover when the latter is in position upon the wheel for the purpose of preventing the removable flange 6 from tilting and thereby becoming disengaged from the wheel. The felloe has an outwardly-directed shoulder 5 to provide additional radial support for the removable flange 6 so that it is possible to make the flange of lighter section than has generally been done heretofore. *(Sealed.)*

190,766. A. E. Sentinella, Harlesden, London. Controls for Motor Vehicles. (6 *Figs.*) September 2, 1921.—The invention relate to controls connected to wires which control the carburettor or the ignition of internal-combustion engines in motor vehicles. According to the invention, the handle bar or steering wheel has pivoted to it an arm and a control lever slides upon and is retained in any position on the pivoted arm. A wire, usually the flexible wire of the Bowden wire by which the throttle is operated, is connected to the lever. The arm is provided with a projection within reach of the thumb or finger so that the arm may be turned upon its pivot causing the throttle actuating lever or air slides to be moved whereby the engine can be accelerated whatever be the initial throttle setting. An arm *a* is pivoted

Fig. 1.

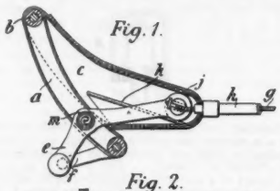
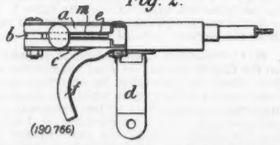


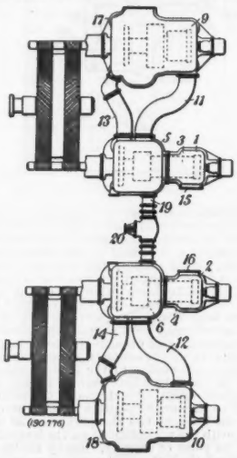
Fig. 2.



at *b* to a plate *c* connected to a handle bar by straps *d*; *e* is a control lever capable of sliding in the arm *a*, which arm can be turned on its pivot by a projection *f* within reach of the thumb (or finger) of the driver. The control lever *e* has attached to it a flexible wire *g* sliding in a Bowden casing *h*, which is anchored to a casing *j* fixed to the plate *c*. On the plate *c* is a rib *k* with which a flange on the lever *e* engages as shown in Fig. 2, and on the lever *e* is a thimble *m* containing a spring which retains the lever *e* in any desired position in the arm. The throttle ignition or air slides may be set in the desired position by moving the control lever along the arm *a*. When it is desired to accelerate, the arm *a* is moved thereby moving the control lever without disturbing the initial setting. *(Sealed.)*

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

190,776. The Hon. Sir C. A. Parsons, K.C.B., Newcastle-on-Tyne, and E. H. B. Anderson, New York. Multiple-Unit Steam Turbine Installations. (4 *Figs.*) September 21, 1921.—The invention relates to turbine installations in which are employed two or more turbines to which the steam is normally supplied in parallel. In the installation illustrated two high-pressure turbines 1, 2 are employed, each having initial stages of blading 3, 4 and final stages 5, 6. The exhaust from the high-pressure turbines is carried to the low-pressure turbines 9, 10 by means of pipes 11, 12 in the case of running ahead, or by pipes 13, 14 for astern running. The high-pressure steam inlets for ahead running are indicated at 15, 16, and the exhaust outlets to the condenser at 17, 18. The high pressure turbines 1, 2 are connected together by a pipe 19 which enters the respective



casings at a point between the initial and final stages of the blading, this pipe being provided with a valve 20. When running ahead at high powers steam is admitted to both inlets 15, 16 and passing through all the ahead stages of both high and low-pressure turbines exhausts from the outlets 17, 18 in the ordinary manner, the valve 20 being closed. When running at low powers, however, the steam is only admitted to one of the inlets 15 or 16, and the valve 20 is opened. Assuming that steam is admitted to the inlet 15, under these conditions it passes through the initial blading stages 3 and is then divided between the final blading stages 5 of the high-pressure turbine 1 and the final stages 6 of the high-pressure turbine 2, passing therefrom to the low-pressure turbines 9, 10 respectively, in the ordinary manner. *(Sealed.)*

TEXTILE MACHINERY.

191,176. J. G. Watson, Knock, Belfast, and J. Kelso, Belfast. Humidifying Apparatus. (2 *Figs.*) October 11, 1921.—The invention relates to apparatus used for producing the required degree of humidity of the atmosphere in weaving. According to the invention, the yarn in a loom is sprayed by a manually-operated device comprising a chamber for containing fluid, with atomiser and manually-operated air pump, the device being so positioned on the loom as to direct the humidifying spray on to the yarn at the back of the loom. 1 is the manually-operated spraying device supported in a carrier 2 secured to the gable 3 of the loom, so that the humidifying spray is directed to that part of the yarn 4 where it is required. The spraying device 1 comprises a chamber for containing water, with an atomiser nozzle and a hand-operated air pump whereby the

Fig. 1.

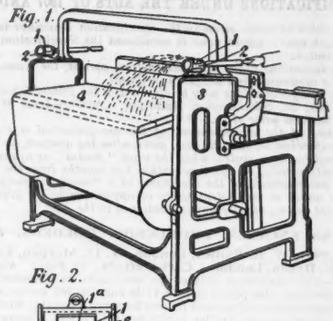
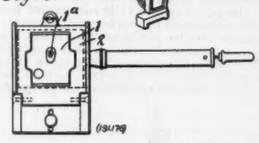


Fig. 2.



atomised spray is projected from the atomiser nozzle 1a. The nozzle 1a is so set and positioned on the loom as to direct the humidifying spray on to the yarn 4 at the back of the loom. The loom shown has two spraying devices, one at each side of the loom so as to ensure the necessary saturation of the yarn, but in the case of narrow looms one device may be sufficient. *(Sealed.)*

MISCELLANEOUS.

190,556. The Briton Brush Company, Limited, Norwich, and H. E. Hovell, Norwich. Brush-Making Machines. (2 *Figs.*) September 29, 1921.—The invention consists broadly of a clamping device for the stock-holders of brush stock filling or boring machines comprising a pair of plates 1 carrying clamping pins 3, one or both of which plates is or are arranged to slide on a member 2. Either or both of the plates 1 may be provided with a number of holes in any of which the clamping pins 3 may be positioned for the purpose of rough adjustment for a given size of stock. A circular back plate 5 is mounted to rotate

Fig. 1.

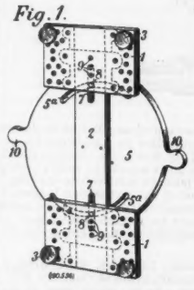
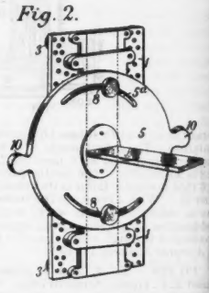


Fig. 2.

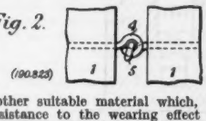


upon a boss or hub carried upon the member 2. Vertical slots 7 are provided in the member 2, and pins 8 attached to the plates 1 pass through these slots and also through curved slots 5a in the circular plate 5. A series of holes 9 may be provided into any of which the pins 8 can be secured. Rotation of the plate 5 by means of the handles 10 will, by reason of the curvature of the slots 5a, cause the pins 8, and consequently the plates 1, to move towards or away from the centre of the device according to the direction of movement, and thus the clamping pins 3 carried by these plates will either grip or release the brush stock. *(Sealed.)*

190,823. H. Cross, Bridgnorth. Reinforced Concrete Road Surfaces. (4 *Figs.*) October 1, 1921.—The invention relates to reinforced concrete road surfaces. According to the invention, the surface is made up of pre-cast moulded concrete slabs 1 of any desired size, shape and thickness having embedded therein a number of longitudinally and transversely-disposed reinforcing bars 2, the ends of which project to some extent from the edges of the slabs, these projecting ends being so shaped or formed that on the slabs being laid side by side the ends of the bars in contiguous slabs may be readily connected together by removable fastening means to form in effect continuous reinforcement throughout the surface after the spaces between the slabs have been filled in, as they are, according to the invention, with

Fig. 1.

Fig. 2.



asphalt or other suitable material which, whilst offering the necessary resistance to the wearing effect of traffic is easily removable as compared with concrete so that the ends of the bars and the removable fastening means are embedded in the said material. The ends of the reinforcing bars may, for example, be formed as horizontally disposed eyes or loops 4, and they may be arranged at slightly different levels for adjacent slabs in such manner that on the slabs being laid side by side at a slight distance apart and with the upper surfaces in the same plane, the eyes or loops of one slab will overlap and coincide with the eyes or loops of an adjacent slab, and the bars of the adjacent slabs may then be readily connected together by passing a key, or the like, 5 through the coinciding eyes or loops from above. *(Sealed.*